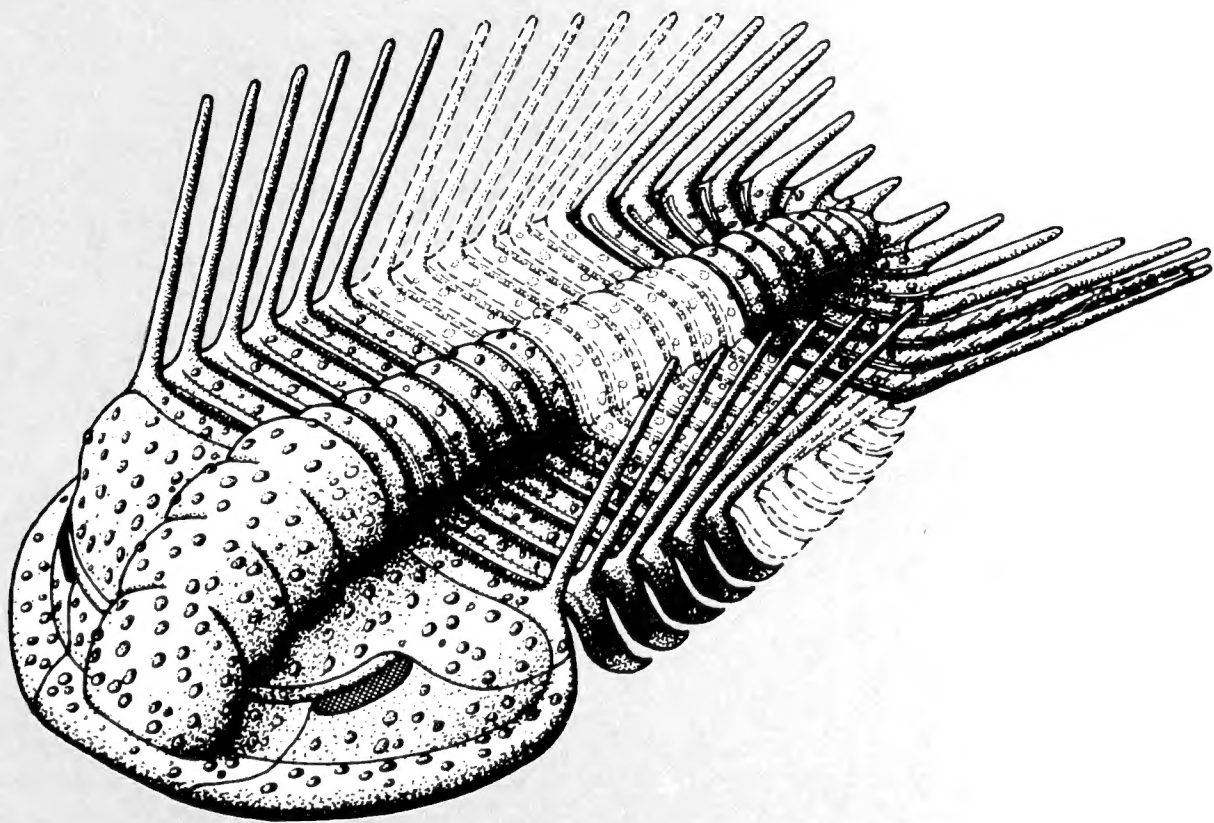


Memoirs of the

Museum of Victoria



Melbourne Australia July 30 1985 Volume 46 Numbers 1 and 2

COVER: Sketch of *Victorispina holmesorum* gen. et sp. nov., described this Memoir from the Digger Island Formation at Waratah Bay, Victoria by P. A. Jell. Drawn by Frank Holmes.

MEMOIRS
of the
MUSEUM OF VICTORIA
MELBOURNE AUSTRALIA

ISSN 0083-5986

Memoir 46
Number 1
July-December 1985

Director
Natural History

VACANT

Deputy Director
THOMAS A. DARRAGH

Editor
DOUGLAS M. STONE

PUBLISHED BY ORDER OF THE COUNCIL

© Museum of Victoria Council 1985

CONTENTS

NUMBER 1

1. Tremadoc Trilobites from the Florentine Valley Formation, Tim Shea area, Tasmania. (Plates 1-13)
BY P. A. JELL AND B. STAIT 1
2. Revision of an Early Arenig Trilobite Faunule from the Caroline Creek Sandstone, near Latrobe, Tasmania. (Plates 14-18)
BY P. A. JELL AND B. STAIT 35
3. Tremadoc Trilobites of the Digger Island Formation, Waratah Bay, Victoria. (Plates 19-33)
BY P. A. JELL 53

“Errata” Memoirs of the Museum Victoria, Volume 45, Number 2, Page 113.
Plate 1 should read:

Parasyngnathus penicillus. Top—GCRL 18542 (female or juvenile male, 97.5 mm SL), Norman R., Qld.

Middle—GCRL 17583 (adult male, 141 mm SL), Oyodo R., Honshu I., Japan.

Bottom—GCRL 15717 (adult male, 132 mm SL), Gulf of Siam.

INSTRUCTIONS TO AUTHORS

The Museum of Victoria was established in 1854 for the purpose of scholarship and education in the fields of natural history and anthropology. The Museum publishes two scientific serials to further these objectives, *Memoirs of the Museum of Victoria* and *Occasional Papers of the Museum of Victoria*.

The *Memoirs* publishes papers on original research in the natural sciences pertinent to Victoria and/or the museum's collections. All contributions are assessed by an independent referee before publication.

The *Reports* are research documents of sufficient importance to be preserved but which are not appropriate for primary scientific publication. Reports are factual rather than interpretive studies, may be of special local interest or may be larger than a normal scientific paper. Contributions will be refereed if appropriate.

Two copies of the manuscript, with any accompanying Plates and Figures, should be submitted initially to the Editor, National Museum of Victoria.

Authors should consult a recent number of the *Memoirs* to acquaint themselves with the format.

Manuscripts must be typed on A4 paper, double-spaced, on one side of paper only, and with ample margins. Captions to Text Figures and Explanations of Plates must be attached to the MS as final pages. Underlining should be restricted to generic and specific names of biological taxa. Measurements must be expressed in the metric system (SI units).

References should be listed alphabetically at the end of the paper. Abbreviations of titles of periodicals must conform with those in *A World List of Scientific Periodicals* (1963-4, 4th ed., London, Butterworth). References to books should give the year of publication,

number of edition, city of publication, name of publisher. Titles of books and (abbreviated) names of periodicals should be underlined in the typed list of references.

Acknowledgements are placed at the end of the paper before References.

Maximum size for **Plates** is 15.15 cm × 21 cm. Photographs must have clear definition and may be submitted as either glossy or flat prints, at **actual size for reproduction**. Each plate (photograph) must be mounted on white card to furnish a white surround of at least 5 cm, and the Plate number clearly labelled on the back of card.

Line drawings for **Text Figures** should be made in black ink on white card or drawing linen. Maximum size (full page) is 15.5 cm × 21 cm: single column width 7.5 cm. Figures are preferably submitted at **actual size**; they may well be drawn larger and photographed by the author to be submitted as glossy prints of required size. Graphic scales must be included with drawings, and on maps and geographic plan views, compass directions should be indicated. Lettering on Figures must be inserted by the author, and special care is needed to ensure that all letters and numerals are still readable when the Figure is reduced.

Oversize illustrations, tables or maps are accepted for publication as **Foldouts** only with the understanding that the author meet any additional costs involved in their production. Maximum size for foldouts is 21 cm × 22.5 cm. They should then be photographed to reduce them to full page size, 15.5 × 21 cm, and submitted as glossy prints. They will be reproduced, and hence must be finally correct when submitted, since they cannot be corrected at the proof stage.

TREMADOC TRILOBITES FROM THE FLORENTINE VALLEY FORMATION, TIM SHEA AREA, TASMANIA

BY P. A. JELL* AND B. STAIT†

* Department of Invertebrate Fossils, Museum of Victoria, 285-321 Russell Street, Melbourne, Victoria 3000.

† Department of Geology, University of Tasmania, G.P.O. Box 252C, Hobart, Tasmania 7001.

Abstract

Trilobites from several horizons in the Florentine Valley Formation of the Tim Shea area west of Maydena, southwestern Tasmania are described and assigned late Tremadoc to possibly early Arenig ages. Their ages approximate the Lancefieldian La1.5 zone of *Psigraptus*, La2 and possibly La3. Taxa described are *Hystericurus penchensis* Lu, *H. lewisi* (Kobayashi), *H. sp. cf. H. robustus* Ross, *Tanybregma tasmaniensis* gen. et sp. nov., *Chosenia adamsensis* sp. nov., *Asaphellus sp. cf. A. trinodosus* Chang, *Megistaspis (Ekeraspis) euclides* (Walcott), *Dikelocephalina asiatica* Kobayashi, *Asaphopsoides florentinensis* (Etheridge), *Scotoharpes lauriei* sp. nov., *Pileklidae* gen. et sp. nov., *Pilekia sp. nov.*, *Protopliomerops hamaxitus* sp. nov. and *P. sp. cf. P. punctatus* Kobayashi.

Introduction

Trilobites of the Florentine Valley Formation in southwestern Tasmania received scant attention until recently. Etheridge (1905) described *Dikelocephalus florentinensis* and *Niobe?* sp. ind. from the Florentine River Valley near The Gap (*vide* Corbett & Banks, 1974). Kobayashi (1936) reassigned the species *florentinensis* of Etheridge to *Asaphopsis* Mansuy, 1920. Kobayashi (1940) described four species from a railway cutting at Junee east of the present town of Maydena near the siding of Fitzgerald (*vide* Lewis, 1940, p. 35); his two species of *Asaphopsis* are considered synonyms of Etheridge's *A. florentinensis*, his two species of *Tasmanaspis* are considered synonymous and *Tasmanaspis* is considered a junior subjective synonym of *Hystericurus* Raymond, 1913. He assigned the fauna to the Lower Ordovician and it may now be correlated with the OT5 to OT7 time interval as discussed below.

Corbett and Banks (1974) illustrated a number of trilobites of the Florentine Valley Formation from The Gap on the Florentine Valley Road and from 5 Road to the southwest. Although they applied numerous specific names and left many other specimens in open nomenclature we consider that they were deceived, by the subtleties of the deformation and failure to employ latex casting on the trilobites, into oversplitting the collection; in our opinion all their hystericurid specimens are referable to *H. lewisi* (Kobayashi, 1940), all the asaphopsid specimens to *Asaphopsoides floren-*

tinensis, the "*Asaphellus*" *lewisi* to *Asaphellus sp. cf. A. trinodosus* Chang, and the *Cybelopsis sp. to Protopliomerops hamaxitus* sp. nov.

Stait and Laurie (1980) provided identifications for new trilobite faunas found in sequence along the Gordon River Road on the western side of The Needles. Our paper along with that of Laurie (1980) provides the detailed palaeontology for the discoveries of Stait and Laurie (1980) and leads to several important revisions of ranges and nomenclature. Findings herein are consistent with the assertions made by Stait and Laurie (1980) about correlations and divisions of the faunas but limitations are placed on the ability to subdivide the faunas referred to by Stait and Laurie (1980) as Assemblages 5, 6, and 7, until more sections are available to confirm previous proposals.

Illustrated material is housed in the Department of Geology, University of Tasmania (prefix UTGD), the Tasmanian Museum (prefix Z), and accessory collections are housed in those institutions and the palaeontological collections of the Museum of Victoria.

We are grateful to Penny Green University of Tasmania, and Annette Jell for curatorial assistance, to Penny Clark for printing the photographs from negatives made by the senior author and to Heather Martin for typing the manuscript.

Localities and trilobite faunas (Fig. 1)

The localities from which trilobites are described are numbered on the fossil locality

register of the Museum of Victoria (prefix NMVPL).

NMVPL1600, 1601, 1602 occur in the yellow siltstone (2nd lithology from base), dark grey calcareous siltstone, and yellow siltstones (near top) respectively, of the Pontoon Hill Siltstone Member (Stait & Laurie, 1980) of the Florentine Valley Formation on the Gordon River Road (19 km west of Maydena), where the member extends on the State Grid Reference—Wedge 8112 from 535, 694 to 529, 685.

- NMVPL1600 *Hystricurus penchiensis* Lu, 1976
Tanybregma tasmaniensis gen. et sp. nov.
Dikelocephalina asiatica Kobayashi, 1934
Pilekia sp. nov.
- NMVPL1601 *Hystricurus lewisi* (Kobayashi, 1940)
Asaphopsoides florentinensis (Etheridge, 1905)
Protopliomerops hamaxitus sp. nov.
Megistaspis (*Ekeraspis*) *eulides* (Walcott, 1925)
Pilekiidae gen. et sp. nov.
- NMVPL1602 *Hystricurus lewisi*
Asaphopsoides florentinensis
Protopliomerops hamaxitus
Hystricurus sp. cf. *H. robustus* Ross, 1951
Chosenia adamsensis sp. nov.
Asaphellus sp. cf. *A. trinodosus* Chang, 1949
Scotoharpes lauriei sp. nov.
Protopliomerops sp. cf. *P. punctatus* Kobayashi, 1934

NMVPL182 and 183. Lower and upper beds respectively at The Gap on Australian Newsprint Mills road into the Florentine Valley from Maydena (see Corbett & Banks, 1974, fig. 4; Stait & Laurie, 1980, fig. 1). Trilobite faunas are identical at the two localities.

Hystricurus lewisi
Asaphopsoides florentinensis
Protopliomerops hamaxitus

5 Road. this locality was detailed by Corbett and Banks (1974, fig. 4, locality 3) as coordinates 440, 400 E. 742, 500 N. on 5 Road in the Florentine Valley.

Hystricurus lewisi
Asaphopsoides florentinensis
Protopliomerops hamaxitus

Adams Falls. Clear Hill Road 400 m east of Adams Falls near junction with Adamsfield Track. State Grid Reference—Wedge 8112: 423, 699.

Hystricurus sp. cf. *H. robustus*
Chosenia adamsensis
Protopliomerops hamaxitus
Asaphellus sp. cf. *A. trinodosus*
Asaphopsoides florentinensis

Age

Correlation of shelly Tremadoc faunas is relatively tentative and considerable disagreement still exists with relationships to a standard scale still a long way off; for example Chugaeva and Apollonov (1982, p. 82) place the shelly fauna zones D, E, and F (of Ross (1951) and Hintze (1953)) in the Arenig whereas Miller *et al.* (1982, p. 177) in the same publication place the same zones in the Tremadoc, and evidence for either does not seem strong.

The fauna from NMVPL1600 (Assemblage 3 of Stait and Laurie (1980) and OT3 of Banks and Burrett (1980)) contains *Psigraptus* which has been used to correlate with the La 1.5 zone of *Psigraptus* of Cooper and Stewart (1979). The trilobites do not provide a distinctive correlation and although *Dikelocephalina* suggests correlation with the *Dikelocephalina* Beds of Kazakhstan (Chugaeva & Apollonov, 1982), the Carranya Beds of the Canning Basin, Western Australia (Legg, 1978), and the *Clarkella* zone of Korea (Kobayashi, 1934) such generic level correlation should be avoided if possible and used only when a number of genera are involved. The medial Tremadoc age suggested by the graptolite is feasible but the implied contemporaneity of the Digger Island Formation (Webby *et al.*, 1981) is doubtful in light of comparison of the trilobite faunas (see discussion in Jell, 1985).

Succeeding faunas of the Florentine Valley formation (Assemblages 4 to 7 of Stait and Laurie (1980) or OT4 to OT7 of Banks and Burrett (1980)) contain and are distinguished by *Hystricurus lewisi*, *Asaphopsoides florentinensis*, and *Protopliomerops hamaxitus*; various other species occur with them at different horizons. The fauna of OT5 may be distinguished from that of OT4 by the appearance of *Chosenia*, *Asaphellus*, and *Scotoharpes* but following more detailed examination of the faunas OT5 to OT7 may not be subdivided on the basis of contained trilobites. Moreover, the utility of a zonal

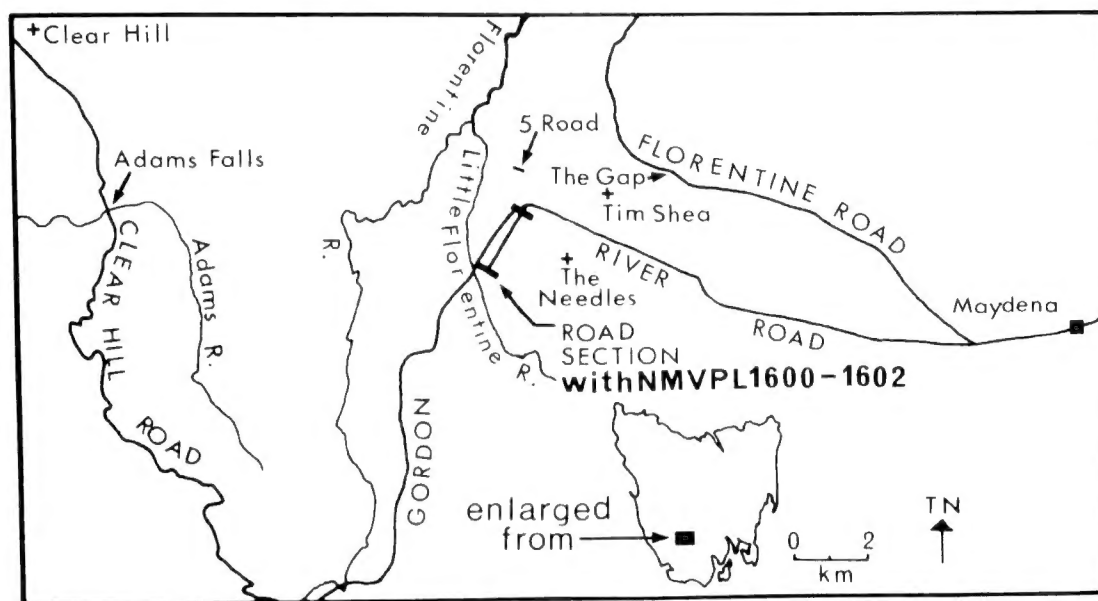


Figure 1. Sketch map of Maydena-Tim Shea area southwestern Tasmania showing fossil localities.

scheme based on faunas of the Florentine Valley Formation will depend on its applicability to other sections which are not yet known. Indeed difficulties of correlating the Digger Island Formation fauna (Jell, 1985) with this section suggest that use of the trilobite faunas to establish a biostratigraphy may be premature and detailed taxonomy of all known sections is necessary before a workable scheme can be established.

The trilobites of these assemblages are not inconsistent with the late Tremadoc to early Arenig age previously suggested (Laurie, 1980; Stait & Laurie, 1980; Banks & Burrett, 1980).

Preservation

The fossils are preserved as moulds in fine-grained decalcified shale to fine sandstone of a variety of colours. There has been considerable distortion of the fossils at all localities but more so at some (e.g., NMVPL1600 and Adams Falls) than at others (e.g., NMVPL182 and 5 Road). The fossils all appear to have lain in the bedding planes and distortion is generally in two dimensions with development of slaty cleavage. Those fossils in decalcified nodules at NMVPL1601 and 1602 are much less deformed than others at the same localities in the shaly

beds. The distortion at NMVPL1600 induced the tubercles on some hystricurid heads to become much more prominent and asymmetrical (Pl. 1, fig. 3) whereas in others it seems to have completely subdued the tuberculation (Pl. 1, fig. 1).

Although it may appear nonsense to place two pygidia (Pl. 5, figs 7 and 8) in the same species, the marked dimensional differences may best be explained as compression from different directions.

It is interesting to note that at NMVPL1600 distortion is marked but there has been no fracture of the exoskeletons (even of the large flat *Dikelocephalina asiatica*) as there is at most other localities particularly in the large flat *Asaphopsoides florentinensis*. The state of preservation of the fossils removes any confidence in the use of any biometrics so no measurements or reconstructions are included in the descriptions; sizes of individuals are indicated in plate explanations and most distinguishing features are not measurements.

Systematic palaeontology

Terminology follows Harrington, Moore & Stubblefield (1959) as far as possible; occipital ring is included in the glabella; all dimensions in

the sagittal or exsagittal directions are discussed in terms of length and all dimensions in the transverse direction are discussed in terms of width (for example the anterior cranial border whose sagittal dimension is often important in specific description is described in terms of long or short in our terminology).

Class Trilobita

Family HYSTRICURIDAE Hupe, 1953

Hystricurus Raymond, 1913

Type species (by original designation):
Bathyurus conicus Billings, 1859.

Hystricurus penchiensis Lu, 1976

Plate 1, figures 1-15

Material: Holotype Nanking Institute of Geology and Paleontology No. 23885 (Lu, 1976, pl. 7, fig. 10), paratypes NIGP23886 to 23888 all from the *Callograptus*? *taitzeoensis* zone of the Yehli Formation in Liaoning Province of northeastern China. Some fifty disassociated cranidia, pygidia, librigenae and thoracic segments as well as two articulated specimens are available from NMVPL1600 including the figured specimens UTGD122500 to 122518.

Diagnosis: Member of *Hystricurus* with subquadrate glabella; relatively long preglabellar field (0.3 of cranial length); palpebral lobe long (0.4 of cranial length), situated posteriorly, becoming wider posteriorly, defined by distinct palpebral furrow parallel to margin of the narrow lobe; librigena with marginal terrace lines, with strong genal spine bearing extension of border furrow down its midline. Pygidium with axis of four rings and short, medially divided terminus reaching border furrow; pleural and interpleural furrows extending to border; border narrow in dorsal view, with high marginal band bearing strong parallel terrace lines; doublure narrow.

Description: Cranidium with coarse tubercular ornament on glabella and cheeks. Glabella without furrows, with straight parallel sides posteriorly, tapering gently over anterior half, with truncated anterior rounded on corners; occipital furrow and ring of about equal length,

with weak apodemal depressions in furrow laterally, with ring tapering laterally behind apodemal pits and passing across axial furrow as very low ridge into posteroproximal corner of fixed cheek, without median node or posterior spines on ring; axial furrow with elongate fossulae at anterolateral corners of glabella, shallowing over axis in front of glabella; preglabellar field weakly convex; anterior border furrow shallow, long, with gently sloping walls front and back, almost transverse, without ornament; anterior border short, weakly convex, without ornament, tapering laterally from near exsagittal line through sides of glabella as facial suture cuts across it; interocular cheek wide, rising up from axial furrow but flat distally; palpebral furrow, running around both anterior and posterior of palpebral lobe to cross facial suture and continue on librigena beneath eye socle; palpebral lobe arcuate, almost semicircular, relatively long at 0.4 of cranial length, sloping up abaxially, becoming wider posterior to the midlength, without ornament; facial suture diverging forward from palpebral lobe in curve to widest point just behind border furrow, then curving strongly across border to anterior margin, running transversely from posterior of palpebral lobe to well beyond lateral extremity of palpebral lobe before turning sharply back for very short distance to posterior margin; posterior cephalic limb short and wide, without ornament, occupied mostly by well impressed transverse posterior border furrow of uniform length, with short convex posterior border behind. Librigena longer than wide, gently convex; with genal spine of more than half cranial length, visual surface almost three times as long as wide (or rather high), standing almost vertically, only weakly convex transversely, apparently holochroal although lenses not clearly distinct; eye socle low, distinct, rim-like beneath visual surface, defined below by broad shallow furrow continuous from palpebral furrow; genal field weakly convex, gently downsloping abaxially from sharp change of slope at furrow beneath eye, with coarse tubercular ornament over adaxial half (tubercles of two sizes) and extremely fine low radial caecal network extending from eye socle

to border; border furrow well impressed, rising steeply up onto border but smoothly up cheek, continuing down genal spine as merging lateral and posterior parts, not running around genal angle; posterior border furrow deeper and lateral border furrow deepening from just in front of genal angle back; border convex throughout becoming much narrower and more convex behind a point just in front of the genal angle, with continuous terrace lines parallel to the margin on anterior part but fading out at the same point the convexity of the border changes; genal spine not continuing curve of cheek margin but running very slightly abaxially, with high convex rims on both sides of deep furrow running down its centre; doublure as wide as border, convex ventrally to enclose cylindrical space in border. Hypostome unknown.

Thorax of at least nine segments (no complete thorax is known); axial rings of uniform length, each with median node; pleural furrows well impressed, beginning at the anterior margin in the axial furrow, occupying most of the length of the segment, fading out down free pleura against back of wide short inclined facet; anterior and posterior pleural bands each with single row of tubercles; pleural tips with posterolateral points.

Pygidium transverse, with convex axis standing above less convex pleural areas; axis tapering slightly posteriorly; axial rings with prominent high tubercle on anterior one and low less-prominent node on second, progressively shorter posteriorly, of uniform length with short wide pseudoarticulating halfrings on first and second; terminus triangular, reaching down to posterior border furrow, divided sagittally into left and right lobes by distinct furrow deepest anteriorly; pleural areas with well impressed pleural and interpleural furrows; with anterior and posterior bands of each rib bearing a transverse row of small tubercles, with all furrows becoming directed more posteriorly towards the posterior where they are almost exsagittal; border extremely narrow in dorsal view, rim-like, of uniform width, defined by shallow posteriorly tapering border furrow, with high marginal band bearing continuous parallel terrace lines, with broad often barely

perceptible posteromedian indentation; doublure narrow, extending in and then up to approach the dorsal exoskeleton beneath the border furrow and enclose cylindrical space within the border.

Remarks: The Tasmanian material is assigned to this Chinese species on the comparison with Lu's (1976, pl. 7, fig. 11) flattened specimen where the glabellar shape is identical with that of the Tasmanian specimens all of which are flattened. Preglabellar, palpebral and occipital structures are identical and there can be little doubt about the specific identity. Although the genal spine looks shorter on Lu's (1976, pl. 7, fig. 12) specimen it seems likely that the ventral mould of the spine is incomplete and may go into the matrix on the counterpart. The internal mould of the pygidium figured by Lu does not allow adequate comparison but observable features are identical, when compared with Tasmanian pygidia of comparable size (e.g., Pl. 1, fig. 15). Lu (1976) compared the Asian species *H. megalops* Kobayashi, 1934 and *H. granosus* Endo, 1935 both of which are distinguished by their narrower more rounded glabellar shape and shorter preglabellar field. *H. flectimembrus* Ross, 1951 has precisely the genal spine structure of the Tasmanian specimens. *Hystricurus wilsoni* Gobbett, 1960 is similar to *H. penchiensis* in ornament as well as in general arrangement of the cranidium and pygidium. However, the Spitsbergen species and *H. flectimembrus* from Utah may be distinguished from *H. penchiensis* by the spines on the rear of the cranidium and on the thoracic segments.

Hystricurus lewisi (Kobayashi, 1940)

Plate 2, figures 1-15; plate 3, figures 9, 10, 13

- 1940 *Tasmanaspis lewisi* Kobayashi, p. 65, pl. 11, figs 3, 4.
- 1940 *Tasmanaspis longus* Kobayashi, p. 66, pl. 11, fig. 5.
- 1974 *Hystricurus paragenalatus* Ross; Corbett & Banks, pl. 1, figs 16, 20, pl. 2, fig. 11.
- 1974 *Hystricurus* sp. Corbett & Banks, pl. 1, figs 21, 25-27, pl. 2, fig. 12.
- 1974 *hystricurus librigenae* Corbett & Banks, pl. 1, fig. 19.
- 1980 *Hystricurus lewisi* (Kobayashi); Staiti & Laurie, fig. 3, Appendix 1.

Holotype: Z151 from 'railway cutting 3.2 km west of June Railway Station' (i.e. just east of

present day town of Maydena) in the Florentine Valley Formation.

Other material: Some 80 to 100 disarticulated cranidia, librigenae, and pygidia from NMVPL182, NMVPL1601, NMVPL1602 and 5 Road including Z150 (holotype of *Tasmanaspis longus*), Z995, material figured by Corbett and Banks (1974), and material figured herein are present in the collections of the Tasmanian Museum, Department of Geology, University of Tasmania and the Museum of Victoria.

Diagnosis: Glabella tapering forward, anteriorly rounded, extremely faint 1p furrow; preglabellar field short, becoming longer with growth; palpebral lobes short, wide, highly arcuate; anterior sections of facial suture diverging to just behind border furrow then cutting across border diagonally over a short transverse distance; librigena with convex border bearing continuous marginal terrace lines running down proximal part of genal spine. Pygidium transverse; axis of four rings and short medially divided terminus without distinct posterior boundary; axial furrow extending almost to posterior border furrow; pleural areas with sharp geniculation forming ridge parallel to margin some distance abaxial to border furrow; border and doublure quite narrow. Pygidium smooth but cephalon with fine tuberculate ornament becoming less obvious with growth.

Description: Small and convex for the genus with variable subdued ornament of pustules on all parts of exoskeleton except in furrows and on the border; cranidium with broadly convex glabella standing above cheeks; glabella with extremely vague suggestions of wide gently-oblique 1p furrows (e.g., pl. 2, fig. 15, centre); axial furrow well impressed, sharper and deeper in front of glabella (probably indicating fossulae) and shallowing adjacent to glabellar lobe 1p; occipital ring short, flat in lateral profile, tapering laterally; occipital furrow sharp and deep, with apodemal pits laterally but then shallowing to almost nothing adjacent to axial furrow; preglabellar field always short, or variable length depending on stage of growth but mostly on post-depositional distortion, downsloping forward into well impressed

transverse border furrow; anterior border of uniform length, short, (may appear to be variable in length due to preservation—steeply upsloping forward was probably original attitude, appearing shorter than on flattened ones), with fine marginal terrace lines; eye lines barely evident on some specimens; palpebral lobe relatively short, arcuate, bulging laterally, flat to slightly downsloping abaxially, situated adjacent to midlength of glabella; palpebral furrow poorly impressed medially but distinct at ends of palpebral lobe, not parallel to lobe margin but rather cutting across base of lobe, continuous around ends of lobe onto free cheek beneath eye surface; posterior cephalic limb wide (glabella only 0.35 of basal cranidial width), subtriangular in shape, with well impressed posterior border furrow becoming longer laterally; posterior border becoming elongate abaxially, short and convex adaxially; facial suture running in fairly straight diagonal line from posterior of palpebral lobe to posterior border, then turning sharply back to margin.

Librigena downsloping abaxially, visual surface vertical, nearly four times as long as high, gently convex in both anterior and dorsal profiles; eye socle low, merely a rim beneath visual surface; furrow beneath eye socle very shallow but distinct without ornament, continuous with palpebral furrow of fixed cheek; genal field with ornament on adaxial part decreasing towards border furrow, gently convex; border furrow well impressed but shallowing distinctly for short section just in front of genal angle, continuing down genal spine where posterior and lateral border furrows merge into one furrow for short distance; doublure as wide as border extending quite a distance forward beyond genal field, terminating forward on an oblique rostral suture.

Pygidium transverse, convex, apparently without ornament; axis of four rings and short widely divided terminus, convex, standing above pleural areas; articulating half ring short standing up high medially; axial rings each of uniform length, becoming shorter towards posterior until fourth ring is extremely short rim; terminus represented by two lobes separated by wide medial depression, not clear-

ly distinguished posteriorly; axial furrow not impressed but expressed as change of slope from axis onto flat proximal part of pleural area, continuing posteriorly down steep slope of pygidium to finish near posterior border furrow (extension down posterior slope may be fourth interpleural furrow simply continuing line of axial furrow but this cannot be determined without knowing termination of axis which in *H. penchiensis* becomes much lower as it extends posteriorly towards the posterior border furrow); pleural area clearly divided by sharp geniculation forming prominent ridge parallel to margin a considerable distance inside the border furrow; adaxial part of pleural area flat, crossed by four long gently sided pleural furrows and three (or four, depending on interpretation of posterior) short sharp interpleural furrows; pleural furrows cutting diagonally back across segment from axial furrow, finishing against ridge of geniculation; interpleural furrows continuing through gaps in geniculation ridge, running down steep outer slope almost to border furrow; outer part of pleural area sloping steeply down to border, smooth except for interpleural furrows; border extremely narrow, tapering forward, merely a flange at base of steeply sloping pleural area, defined by poorly impressed border furrow at change of slope, with fine parallel continuous terrace lines along margin; doublure narrow, convex, leaving cylindrical space in border; articulating facet small sloping steeply abaxially; pygidium without ornament.

Remarks: Kobayashi (1940) nominated this species as the type for his genus *Tasmanaspis* and the holotype is an internal mould, refigured herein (Pl. 2, fig. 2), of a medium sized cranium. The features quoted by Kobayashi as distinguishing *Tasmanaspis* are not of generic significance in the modern understanding of *Hystricurus* and the "concavo-convex curvature of the frontal limb and rim" is considered to appear distinctive only by virtue of the preservation at the type locality. *Tasmanaspis* is undoubtedly a junior synonym of *Hystricurus*.

Angle of the facial suture and elongate cranium, quoted by Kobayashi (1940) as distinguishing *Tasmanaspis longus* from *T.*

lewisi are the result of lateral compression as opposed to sagittal compression in the type of *H. lewisi*. The eye ridge and length of occipital ring are not distinctive and the relative length of preglabellar area and position of palpebral lobe are not quoted accurately because Kobayashi's illustration of the type of *H. lewisi* is retouched in the left posterior region; the posterior cephalic limb is not preserved and the posterior margin of the occipital ring is not evident either, Kobayashi's specimens from Junece have been flattened during diagenesis as well as distorted and this flattening has produced the apparent elongation of the preglabellar area. However the distance from the depth of the border furrow to the tip of the border is approximately the same in most of the larger specimens from the other localities listed above. Perhaps most important of all is structure of the palpebral lobe which in mature specimens (e.g. Pl. 2, fig. 13) has the palpebral furrow well away from the margin at the midlength of the highly arcuate lobe just as it is in the holotype. In juvenile specimens this lobe is much narrower. As this and all other non-dimensional features match, the identity of these recent collections as *H. lewisi* is almost certain.

The wide flat palpebral lobes approach *Parahystricurus* Ross, 1951 and although the forward position of the lobes is distinctive of that genus the closest species to *H. lewisi* may well be *P. pustulosus* Ross, 1951 and related forms.

The pygidium resembles closely that figured by Ross (1951, pl. 19, figs 6, 11, 15) from his zone E with the marked ridge on the pleural area particularly distinctive. Ross's suggestion that it probably belongs to *Parahystricurus carinatus* Ross, 1951 further suggests alliance of *H. lewisi* with *Parahystricurus* although it is suggested below that Ross's pygidium may belong to *Hystricurus robustus* which occurs at the same locality.

Hystricurus megalops Kobayashi, 1934 from Korea and *H. granosa* Endo, 1935 from Liaoning, China resemble each other as well as *H. lewisi* in glabellar shape, ornament and most proportions of the cranium so that the three may prove ultimately to be synonymous but we prefer to retain the Tasmanian name until a

fuller understanding including knowledge of pygidia is available for each of the Asian species.

***Hystricurus* sp. cf. *H. robustus* Ross, 1951**

Plate 3, figures 8, 11, 12; plate 4, figures 1-7

Material: Some 20 to 30 cranidia librigenae, and pygidia from NMVPL1602 and from the Adam's Falls locality.

Description: Ross (1951, p. 51, 52) gave a detailed description of this species so only those features that add to or are at variance with his description are mentioned here. Ross's specimens are smaller than these Tasmanian individuals so some of the features that do not match exactly are probably due to comparison of different growth stages of the species. In the Tasmanian material the palpebral lobe is even wider and just a little shorter; the facial suture runs directly forward from the anterior of the palpebral lobe (Pl. 4, figs 1, 3) (distortion of individuals in Pl. 4, figs 4, 6 erroneously suggests divergence) and runs diagonally back to the margin from the rear of the palpebral lobe; on the librigena the genal spine is deflected a little more noticeably laterally and does not exhibit the same adaxial curve in its posterior part.

The pygidium figured by Ross (1951, pl. 19, figs 6, 11, 15) from the same locality as the cranidia named *H. robustus* are identical with the Tasmanian pygidia and may belong to this species rather than *Parahystricurus carinatus* as suggested by Ross in the explanation of his plate 19. Moreover the thorax assigned to *H. robustus* (Ross, 1951, pl. 14, fig. 27) is identical with the Tasmanian specimen (Pl. 3, fig. 12) in all observable features.

Remarks: This species is difficult to distinguish from *H. lewisi* with which it stands out from the rest of the genus by virtue of its palpebral structure. However the two may be separated by *H. robustus* having coarser tuberculate ornament overall, much shorter preglabellar field, exsagittal to converging course of facial sutures forward of palpebral lobes, and occasional tubercles on the pygidial pleural ribs. The resemblance of the pygidia of the two species is remarkable as the only distinguishing feature is the fine pustules on internal moulds and rare

course pustules on the external surface of *H. robustus*.

***Tanybregma* gen. nov.**

Etymology: From the Greek *tany* meaning long and *bregma* meaning front of the head; the reference is to the considerable preglabellar length.

Type species: *Tanybregma tasmaniensis* sp. nov.

Diagnosis: Cranidium subquadrate, of low convexity, with tuberculate ornament of two different sizes on glabella and interocular cheeks; glabella tapering forward, truncated anteriorly, with long 1p furrow at high angle to transverse line; preglabellar length more than 0.35 total cranial length, with well developed caecal network, gently downsloping forward; anterior border short, upturned; palpebral lobe long, situated posteriorly, arcuate but narrow, limited by well impressed palpebral furrow; facial suture diverging forward from palpebral lobe to widest point near anterior of border furrow, transverse behind palpebral lobe. Librigena with extremely wide doublure reaching well forward of genal field and terminating there in a rounded rostral suture.

Remarks: This genus is based on cranidia and librigenae only but it is possible that the pygidium is so similar to that of the co-occurring *H. penchiensis* that it is not possible to separate them in the deformed state in which they are found. Cranial features are reminiscent of *Hystricurus* but the longer preglabellar field, 1p furrow, row of denticles on the adaxial side of the genal spine and in particular the wide doublure and curved rostral suture distinguished *Tanybregma*. It has some similarity to a number of genera but none has the combination of *Tanybregma*; *Nyaya* Rozova, 1968 is shorter in front of the glabella, has longer less arcuate palpebral lobes and is smooth but it does have a pygidium that could easily be confused with that of *H. penchiensis*. Some species of *Hystricurus*, namely *H. spp. A* and *E* of Ross (1951, pl. 9, figs 31, 34, 37 and pl. 15, figs 10, 11, 13, 14) show a tendency towards preglabellar elongation so it is not unreasonable to suggest that *Tanybregma* may

have arisen out of a form like *H. penchiensis* with the features cited above sufficient to warrant generic separation. *Hyperbolochilus* Ross, 1951 (type species *H. marginauctum* Ross, 1951) is superficially similar but its short palpebral lobes, glabellar shape and course of its rostral suture are distinctive at the generic level. *Hystricurus* (*Guizhouhystricurus*) Yin in Yin & Li, 1978 (type species *H. (G.) yinjiangensis* Yin & Li, 1978) has the long preglabellar field of *Tanybregma* but is clearly distinguished by its short convex anterior border and palpebral structure indicating placement in a separate hystricurid lineage.

***Tanybregma tasmaniensis* sp. nov.**

Plate 3, figures 1-7; plate 8, figure 7

Etymology: This species name refers to its discovery in Tasmania.

Material: Holotype UTGD95983, paratypes UTGD96674, 96676, 122528 to 122531 and 122554 plus some 10 to 15 cranidia and librigenae in the collection of the Museum of Victoria, all from NMVPL1600.

Diagnosis: As for genus.

Description: Cephalon semicircular, of low convexity; cranium a little longer than wide but generally subquadrate; glabella with gently curved sides converging forward, truncated anteriorly by transverse preglabellar furrow and rounded anterolateral corners, with well impressed 1p furrow extending from close to axial furrow at level of midlength of palpebral lobe in a straight line at high angle to transverse to finish close to occipital furrow near sagittal line; occipital furrow deep, steep sided, with flat bottom, with wide deeper apodemal pits laterally separated from axial furrow by narrow very shallow part of furrow; occipital ring of uniform length, without median node, convex in lateral profile; axial furrow well impressed but shallowing anteromedially and posteriorly; preglabellar field long, gently downsloping, with typical caecal network, approximately equal in length to the border plus border furrow; border furrow long, shallow; anterior border concave, flattening out near border, upturned, of uniform length throughout; eye ridge narrow and relatively long, consisting of

two parallel trunks, separated from palpebral lobe by sharp extension of palpebral furrow; palpebral lobe with short very narrow exsagittal anterior section, remainder arcuate, almost semicircular, of uniform width, narrow, defined by well impressed palpebral furrow, more than half as long as glabella, situated posteriorly; palpebral furrow cutting off eye ridge from beneath eye socle on librigena; facial suture diverging forward from anterior of palpebral lobe to be widest at border furrow, cutting fairly directly across anterior border but then running along close to anterior margin for some distance before reaching margin, almost transverse behind palpebral lobe, extending well beyond abaxial extremity of palpebral lobe then curving posteriorly to reach margin at high angle; posterior cephalic limb short, wide, with well impressed posterior border furrow near anterior, with highly convex abaxially-elongating posterior border occupying most of its length.

Librigena smooth, with long genal spine; visual surface at high angle to genal field, of uniform width, with well rounded ends, apparently holochroal; eye socle low, simply a rim appearing like a piece of wire lain beneath the visual surface; genal field sloping gently out to border furrow, longer than wide; border furrow wide and shallow as on anterior of cranium, continuing posteriorly down length of genal spine after merging of posterior and lateral border furrows just behind genal angle; border narrow, convex, sharply upturned, with subdued terrace lines laterally; genal spine quite long, with posterior border bearing set of 9 or 10 or more distinct denticles as it runs down adaxial side of genal spine; doublure wide, with well developed parallel continuous anastomosing terrace lines, developing into angular ridge running down centre of genal spine beneath border furrow, extending some distance forward of the genal field where it terminates against an adaxially convex rostral suture.

Family LEIOSTEGIIDAE Bradley, 1925

***Chosenia* Kobayashi, 1934**

Type species (by original designation): *Chosenia laticephala* Kobayashi, 1934 from the

Early Ordovician *Clarkella* Zone at Saisho-ri, South Korea.

Diagnosis: Leiostegiid with weakly impressed glabellar furrows; glabella truncated anteriorly; anterior border shorter and more convex in front of glabella, longer and flatter laterally; strong caecal trunk issuing from anterolateral corner of glabella, crossing axial furrow but not continuing; eye ridges beginning much further back in axial furrow, oblique (c. 45°) to exsagittal line; palpebral lobes short, situated posteriorly. Pygidium transverse; anterior border furrow curving back strongly behind articulating facet and running to margin in front of marginal spine; with relatively wide border; pair of long marginal spines issuing from first, second or third pygidial segment; pleural furrows well impressed; interpleural furrows evident.

Other species: Apart from the type and *C. adamsensis* described here, only *C. divergens* Lu, 1975 from the *Acanthograptus-Tungtzuella* Zone (late Tremadoc) of the Fenhshiang Formation at Yanshuiping, Changyang, western Hupeh Province, China is assigned to this genus.

Remarks: The type species was poorly illustrated and does not provide sufficient morphology upon which to interpret a separate genus. The fragmentary holotype cranidium (Kobayashi, 1934, pl. 8, fig. 8) is particularly unsatisfactory. However, one paratype pygidium (Kobayashi, 1934, pl. 8, fig. 11) shows sufficient morphology to be confident that it is congeneric, if not conspecific, with *Chosenia divergens*. Pygidial characters of the genus may be discerned from Lu's (1975, pl. 2, figs 28-31; pl. 3, figs 1, 2) well illustrated pygidia. However, the only cranidium figured by him is also fragmentary and reveals only a few more features than the type species.

Assignment of *Chosenia adamsensis* sp. nov. is discussed under that species below but its inclusion allows a somewhat more complete understanding of the morphology and systematic position of *Chosenia*. The cranidium is almost identical with that found in some species of *Leiostegium* Raymond, 1913 (c.g. *L.*

ulrichi Berg & Ross, 1959, pl. 21, figs 1, 6). There is undoubtedly a close relationship between the two genera but features of the pygidium other than the marginal spines (see discussion of species below) are critical in this group of trilobites. Taking the pygidia into consideration the well impressed pleural furrows are probably most distinctive; also important is the course of the border furrow anterolaterally. These features along with the larger anterior fixigenal area on the cranidium, laterally longer anterior cranial border and glabellar shape distinguish *Chosenia* from *Evansaspis* Kobayashi, 1955 whose type species is *E. glabrum* Kobayashi, 1955 from the Lower Ordovician McKay Group in British Columbia. *Evansaspis* resembles *Chosenia adamsensis* specifically only in the position of its pygidial marginal spines as discussed below. A case for considering *Chosenia* a subgenus of *Leiostegium* could be made on the basis of the similarities between *C. adamsensis* and *Evansaspis* but we consider that the pygidial structure of *Chosenia* indicates a separate lineage worthy of generic separation but included in the same family. How each of these groups is related to *Leiostegium* and its origins is not yet apparent but if its origin is from the Kaolishaniidae as seems most likely then one of these lineages may have produced *Leiostegium* by loss, possibly into the thorax, of the macroleural segment. The possibility should be investigated that the *Chosenia* line may have emerged from the Mansuyiinae with its ornamented pygidial spines, well impressed pleural furrows, subtle pygidial border, posterior eyes and large faint glabellar furrows and that *Evansaspis* may have emerged from the Kaolishaniidae with more prominent pygidial borders, less distinct pleural furrows, and better impressed lateral glabellar furrows. If this proves to be so then the Leiostegiidae would be polyphyletic.

Leiostegium (*Leiostegium*) *floodi* Shergold, 1975 from the early Tremadoc *Oneotodus bicuspatus* with *Drepanodus simplex* zone of the lower Ninmaroo Formation at Black Mountain, western Queensland may well be a species of *Chosenia* also but it is not possible to distinguish the genera on cranidia alone.

***Chosenia adamsensis* sp. nov.**

Plate 4, figures 8-11; plate 5, figures 1-10

Etymology: Named for Adam's Falls near the type locality of this species.

Material: Holotype UTGD122535, and paratypes UTGD95175, 95927, 95942, 95945, 96023, 96025, 96027, 96029, 96602, 96611, 96637, 96642, 96646.

Diagnosis: Member of *Chosenia* with well impressed palpebral furrows, tuberculate ornament, pair of long curving pygidial marginal spines from second or third segment of pygidium.

Description: Moderately large convex species (cephala up to 2.5 cm long); surface ornament of fine sparsely scattered tubercles over whole exoskeleton. Cranidium subquadrate, with glabella lower than cheeks; glabella with straight sides, tapering slightly forward, with anterior truncated to broadly curved, highly convex in anterior profile; lateral glabellar furrows in 4 pairs not evident on all specimens, shallow, indistinct; 1p furrow directed obliquely back from the axial furrow but then curving to be transverse and shallower but continuous sagittally in smaller specimens, discontinuous in larger specimens; 1p and 2p furrows joining in axial furrow in smaller individuals, appearing as a Y-shaped furrow in larger individuals; 2p, 3p and 4p approximately parallel to 1p but not curved adaxially and not continuous over axis, becoming progressively shallower and shorter forward, 4p in front of eye ridge, and not reaching axial furrow, 3p meeting axial furrow just behind eye ridge; tuberculate ornament on lateral glabellar lobes but not furrows; occipital furrow well impressed, long, with steeper wall in front than behind, transverse medially but with narrow posteriorly sloping lateral sections accommodating apodemes; occipital ring of uniform length, flattened on top in lateral profile, with only extremely vague antero-median node; axial furrow deep and wide, of uniform width, with a pair of strong fossulae at anterior border furrow and another pair of prominent pits just behind the strong ridge (caecum) extending out of the anterolateral corner of the glabella across the axial furrow and

fading into the cheek; crossed by low ridge from anteriorly-curving occipital ring into posterolateral corners of cheeks; preglabellar field absent; anterior border furrow deep and long in front of glabella, shallower and shorter in front of cheeks, with almost vertical wall up onto border and steep but gentler slope posteriorly; anterior border highly convex, flattened and sloping forward in lateral profile, longer laterally (before tapering along facial suture), excavated posteromedially by the border furrow thrust forward in front of the elongate glabella, with continuous terrace lines near and parallel to the margin; eye ridge prominent, composed of two parallel caeca, at approximately 45° to transverse, meeting but not crossing axial furrow well back from (nearly 0.3 of glabellar length) glabellar anterior; palpebral lobe strongly arcuate, short, situated opposite posterior third of glabella, strongly elevated and then flattened on top medially; palpebral furrow well impressed shallowing over mid-length, parallel to lobe, running across eye ridge at junction with palpebral lobe, turning down around posterior of the lobe; facial sutures diverging slightly forward from anterior of palpebral lobes to border furrow, cutting diagonally at low angle to transverse across anterior border, highly arcuate around palpebral lobe then dropping down almost vertically and slightly posteriorly to the posterior margin in the same exsagittal line as the outermost point on the palpebral lobe; posterior border furrow well impressed, of uniform length throughout, transverse; posterior border short, convex, of uniform length throughout, strongly downturned as part of cephalic posterolateral limb beyond articulating point directly behind posterior of palpebral lobe.

Librigena with broad, gently convex genal field; eye socle high, vertical, marked off by a wide poorly-impressed furrow; border composed of two distinct parts separated by a shallow furrow, rather flat; outer part narrow, with continuous comarginal terrace lines continuing across facial suture onto cranidium, terrace lines running over margin at end of outer part of border near midlength of eye, tapering to nothing before level of posterior border furrow; inner part of border broader than outer

part, beginning anteriorly with a smooth area just behind the facial suture and continuing posteriorly into a long strong genal spine, with less-regular sometimes anastomosing longitudinal terrace lines that continue down the genal spine; border wide in area of overlap of two parts but rather narrow anteriorly and with strong reduction in width posteriorly at the spine base; posterior border short and highly convex; border furrow short and deep posteriorly, with small re-entrant in base of genal spine (elongate into a furrow down the spine in one specimen) where posterior border furrow comes to genal spine, shallow laterally, continuing in curve onto cranium; rostral suture running adaxially towards posterior.

Thorax of 10 segments, of uniform width; axis with deep axial furrow having narrow posteriorly-sloping parts and apodemes as in occipital furrow; articulating half-ring short, smooth, almost as high as ring; ring of uniform length running back from axial furrow for short distance then transverse medially; axial furrow weakly impressed; pleurae flat to articulating line then gently down turned beyond; well impressed pleural furrows occupying most of length of pleura as far as articulating line, then tapering to nothing against the posterior of the facet in a short distance; anterior and posterior pleural ribs of equal length; pleural extremities with free spines (as shown by extent of doublure on internal mould), with large facets over full width and occupying full length for distal half, half as wide as fixed pleurae; prominent processes at lateral articulating points.

Pygidium subtriangular to semicircular, of moderate convexity; axis of seven (or eight in larger specimens) rings and short terminus, tapering to rounded posterior, reaching close but not quite to the inner edge of the doublure, transaxial furrows transverse, progressively shallower posteriorly; pleural areas convex, with well impressed pleural furrows becoming less distinct and narrower posteriorly and not extending onto the border region; anterior border furrow (i.e. first pleural furrow) very well impressed especially laterally behind the long narrow sloping and indistinct facet, curving strongly back in this area and running to the

margin in front of spine; interpleural furrows evident on first three pleural ribs; border furrow shallow, indistinct, beginning behind marginal spines; border relatively narrow, of uniform width, with some terrace lines near the margin, convex near the border furrow then flatter and down sloping distally; pair of marginal spines issuing from second or in some specimens third segment of pygidium, long, curving adaxially, with fine longitudinal discontinuous and rarely anastomosing terrace lines; doublure convex ventrally, with well developed continuous and anastomosing terrace lines, widest anteriorly, narrowest sagittally, swinging around anterolateral corner to finish at lateral articulating process.

Remarks: This species is assigned to *Chosenia* on the basis of the cranial similarities with Lu's (1975, pl. 2, fig. 27) *C. divergens* and on pygidial features behind the segment carrying the macropleural marginal spine. We suggest that the more posterior position of the spine in *C. adamsensis* is due to the fact that one or two thoracic segments remained ankylosed in the pygidium (i.e. not released into the thorax) whereas in *C. divergens* these segments have been released forward so the marginal spines appear on the first pygidial segment. This is reinforced by the pleural furrows in front of the spine running to the margin in *C. adamsensis*. The variation between second and third pygidial segment being macropleural in this species indicates that it is not an important feature and that the first segment being macropleural in *C. divergens* is a relatively minor distinction phylogenetically. We consider it a specific taxobase and further the pleural furrows and posteriorly turned anterior border furrow are considered generic taxobases. For this reason we consider *Perischodory* Raymond, 1937 and *Evansaspis* Kobayashi, 1955 belong to a separate lineage within which they may be congeneric, despite Berg & Ross (1959, p. 114), by analogy with *C. divergens* and *C. adamsensis* in their lineage. With the origin of pygidial marginal spines as incorporated macropleural segments in mind, better understanding of species relationships in these groups may be achieved.

The considerable variation among available specimens of *C. adamsensis* is partly due to intraspecific variation and partly due to distortion after burial. The latter is easily recognised in the transverse or elongate pygidial shape but the former is more difficult to discern. Position of the pygidial marginal spines is variable between the second and third pygidial segments and the structure of the 1p and 2p glabellar furrows is also variable from being two discrete furrows to being a single Y-shaped furrow but this latter feature may change during growth. The identity of 1p and 2p combined into one rather than a single Y-shaped 1p is clear.

Family ASAPHIDAE Burmeister, 1843

Asaphellus Callaway, 1877

Type species (by original designation): *Asaphus homfrayi* Salter, 1866.

Asaphellus sp. cf. *A. trinodosus* Chang, 1949

Plate 4, figure 12; plate 6, figures 1-12

Material: UTGD95877, 95895, 95917, 96002, 96005, 96032, 98111, 98117, 98137 and 122536 to 122539 all from NMVPL1602.

Description: Cranidium of extremely low convexity, without obvious furrows; glabella barely outlined by an extremely subtle change of slope onto the cheeks, broad at base (approx. 0.5 cranial width) tapering forward, about 0.83 of cranial length, with low inconspicuous median node 0.16 of cranial length from posterior margin; occipital furrow barely evident, very near posterior margin; cheeks narrow, with narrowest point at anterior of palpebral lobes; palpebral lobes flat, situated with anterior of lobe at midlength of cranidium, comparatively long, broadly arcuate; prelabellar area flat; posterior limb downsloping abaxially, with long extremely shallow posterior border furrow parallel to and close to the posterior margin, with blunt lateral margin at facial suture; facial suture isoteliform, hardly diverging forward of the palpebral lobes, with widest point forward of palpebral lobes well behind glabellar anterior, curving smoothly forward to the ogive in the midline, running straight back from rear of palpebral lobe for short distance then curving

smoothly abaxially but never transverse (always oblique back) then curving smoothly into an exsagittal line to meet posterior margin at right angle; posterior margin transverse. Librigena long and relatively narrow, of low convexity like the cranidium; eye socle vertical, low, defined below by the change of slope onto the flat genal field but also with a wide shallow furrow around its base; border furrow broad and very shallow, fading out anteriorly, swinging adaxially into the posterior border furrow well before base of genal spine; border narrow, weakly convex, of uniform width, with some weak longitudinal terrace lines near posterior; genal spine short, tapering strongly, with fine longitudinal terrace lines extending along it, continuing the line of the lateral margin of the cheek to its tip. Hypostome incompletely known from only one specimen (Pl. 6, fig. 10). Median body broadest at posterior of the anterior wings, subcircular, of low convexity, with fine ornament of concentric terrace lines about an anteromedian point; posterior lobe only 0.2 of length of median body; median furrow as two oblique lateral clefts, connected to lateral border furrow by very much shallower more exsagittal furrow; anterior border flat, with gently arched anterior margin; posterior border short, convex, isolated by longer well impressed border furrow, with median elongation.

Pygidium of low convexity, with poorly impressed furrows, semicircular or just slightly more transverse in dorsal view; axis broadly convex in anterior profile, flat in lateral profile, of nine rings plus posteriorly rounded terminus, rings becoming shorter and less well defined posteriorly, tapering strongly along anterior three or four rings then tapering only slightly if at all, apparently widening again at terminus in some specimens; transaxial furrows transverse, with slightly deeper apodemal pits laterally, extending to inner edge of doublure; pleural areas with extremely shallow pleural and interpleural furrows visible on a few specimens; axial furrow not impressed, marked by small change of slope from axis to pleural area; anterior border furrow well impressed behind lateral articulating process, fading out about halfway along width of articulating facet, straight, sloping a

little to posterior abaxially; facet steep, wide, flat, longest near middle of doublure; border furrow very wide and shallow, parallel to border, finishing against facet; doubleure almost as wide as anterior of axis, relatively wide, with distinct, parallel, continuous terrace lines.

Remarks: This material is assigned to *Asaphellus* rather than *Megistaspis* on the basis of its long glabella, almost effaced axial furrow, larger eyes, and different hypostomes. Within *Asaphellus* it is related to a group of Tremadoc species from Argentina (*A. catamarcensis* Kobayashi, 1935 (see Harrington & Leanza, 1957, p. 147), *A. jujuanus* Harrington & Leanza, 1957, and *A. riojanus* Harrington & Leanza, 1957), from Korea (*A. tomkolensis* Kobayashi, 1934) and from China (*A. changi* Sheng, 1958, *A. inflatus* Lu, 1959, *A. trinodosus* Chang, 1949, *A. praetrinodosus* Lu, 1976 among others). Of this array of virtually indistinguishable species the Tasmanian material seems most closely comparable with *A. trinodosus* in so far as subtle swellings are barely apparent just behind the palpebral lobes in a similar position to the more obvious ones of the Chinese species. The course of the facial suture just behind the palpebral lobe seems distinctive of the Tasmanian material but this hardly seems sufficient to erect a species especially within such a difficult taxonomic complex of essentially contemporary species.

Megistaspis (Ekeraspis) Tjernvik, 1956

Type species (by original designation): *Plesiomegalaspis (Ekeraspis) armata* Tjernvik, 1956.

Megistaspis (Ekeraspis) euclides (Walcott, 1925)

Plate 7, figures 1-15

- 1925 *Xenostegium euclides* Walcott, p. 126, pl. 24, figs 13, 14.
 1925 *Xenostegium albertensis* Walcott, p. 125, pl. 24, figs 10, 11.
 1955 *Kayseraspis (?) euclides* Walcott; Kobayashi, p. 442, pl. 4, figs 4-12; pl. 5, figs 8-10.

Syntypes: USNM70364 and 70365 (figured by Walcott, 1925, pl. 24, figs 13, 14) from Mons Formation, Sawback Range, British Columbia.

Material available: Some 40 or 50 fragmentary and distorted specimens are available from NMVPL1601 including UTGD95994, 98095, 98102 and 122540 to 122551.

Diagnosis: Ekeraspid with very low convexity, axial furrow extremely poorly impressed; glabella with rounded anterior, waisted at level of palpebral lobes; palpebral lobes small, wide, semicircular, situated behind midlength of cranidium; facial suture diverging forward of palpebral lobes, concave forward of palpebral lobe to widest point, sigmoidal behind palpebral lobe, meeting posterior margin at large angle, as it runs posteroaxially. Free cheek with long genal spine. Hypostome highly convex, with complete rounded posterior margin, with widest point near midlength. Pygidium subtriangular, with long terminal spine decreasing in length with growth; pleural and interpleural furrows weakly impressed on anterior segments.

Description: This description only refers to additions or modifications to that of Kobayashi (1955, p. 442). Occipital furrow evident only on internal moulds, extremely shallow, relatively very close to posterior margin. Palpebral lobe comparatively short, close to glabella, wide, semicircular, flat but slightly elevated, situated near midlength of glabella and behind midlength of cranidium. Facial suture diverging slightly forward from palpebral lobes, with widest point forward of glabellar anterior, then anteriorly concave to anteromedian point, curving laterally a short distance behind the palpebral lobes, then almost transverse but always slightly oblique, then curving posteriorly to be exsagittal and curving back towards the axis near posterior margin to give rounded margin to extremity of posterior cephalic limb.

Librigena with broad flat genal field, without border furrow; eye socle low, vertical, prominent; genal spine long, almost circular in section but with strong ridge running down ventral side, with distal part in exsagittal line; doublure, wide, elongate anteriorly, in transverse section slightly upturned adaxially to remain flush against dorsal exoskeleton, with strong parallel terrace lines from base of genal spine to median suture of isotelliform suture

pattern, with terrace lines diverging and increasing in number by intercalation anteriorly. Hypostome convex, subquadrate, covered with terrace lines more or less concentric about an anteromedian point on the high part of the median body; median body longer than wide, rounded anteriorly, with well-impressed median furrow dividing it into large anterior lobe and very short low posterior lobe; median furrow at high angle to transverse line laterally, not continuous across axis; anterior wings short almost vertical, well ornamented; shoulder wide, fairly flat, tapering strongly both forward and back; border furrow well impressed laterally, not connected directly to anterior border furrow, running most distinctly into median furrow but also connected by shallow furrow with posterior border furrow; posterior margin complete, short medially, covered with terrace lines; anterior border furrow cutting across anterior wing to margin in front of lateral notch. Thorax of six or more segments (complete specimen not available); pleural furrow beginning at anterior in axial furrow, in midlength for most of its course, fading out about the midwidth of the free pleura, deepest crossing articulating line; thorax typically asaphid.

Pygidium triangular, with long posterior spine becoming relatively shorter with growth; axis long, slightly tapering, almost parallel sided, with seven barely discernible rings and a long axis consisting presumably of several more rings that are not defined; pleural fields with poorly impressed pleural furrows anteriorly, with even fainter interpleural furrows on the ribs, with well impressed anterior border furrow identical with the thoracic pleural furrows; articulating facet wide, steeply inclined; border furrow not impressed; doublure of moderate width, with well developed parallel and anastomosing terrace lines, close beneath dorsal exoskeleton; posterior spine circular in section, connected to posterior of axis by low ridge across border area in some specimens.

Remarks: This species was erected by Walcott for pygidia and a hypostome and the interpretation of the cephalon depends upon Kobayashi's (1955, pl. 4, figs 5, 10; pl. 5, fig. 8) assignment

of cranidia. The Tasmanian material, where only one asaphid species occurs at the horizon in question, confirms his association and all that remains is for this type of cephalon to be discovered at the type locality. However, morphology of the species is now well established. Kobayashi (1955) recognised the alliance of the species with *Megistaspis* but assigned it to *Kayseraspis* Harrington, 1938 without commenting on the reasons. The parallel-sided glabella, shorter glabella, more posterior eyes, triangular pygidium and longer stouter posterior spine distinguish this species from *Kayseraspis*.

Family DIKELOKEPHALINIDAE Kobayashi, 1936

This family was placed with the asaphids by Harrington *et al.* (1959) probably by association with the Taihungshaniidae which were correctly placed in the Asaphoidea. The Dikelocephalinidae have a glabella usually about 0.6-0.7 of cranial length while asaphids have a much longer glabella. In the pygidium the critical taxobase is the attitude of pleural furrows—relatively transverse in asaphids but strongly curved backwards in the dikelocephalinids. The Taihungshaniidae and Dikelocephalinidae both possess a pair of pygidial marginal spines but these are homeomorphous structures shared with a great many other trilobites as well. It appears far more likely that the Dikelocephalinidae evolved from the Dikelocephalidae as suggested by Kobayashi (1936, 1960). The brief remark by Fortey and Peel (1983, p. 54) that the Dikelocephalinidae are probably related to the Ceratopygacea would need some amplification if it is to be taken seriously especially in light of the prominent occipital node (Pl. 8, fig. 7); position of the node, forward of the occipital furrow rather than on the occipital ring, was used to relate *Macropyge* to the Ceratopygacea (Owens *et al.*, 1982) so some discussion of the importance of this feature would seem appropriate. The Hungaiidae Raymond, 1924 may have a similar origin and these two derived families could be synonymous.

Dikelocephalina Brøgger, 1896

Type species (designated Vogdes, 1925): *Cen-*

troleura ? *dicraeura* Angelin, 1854 from the Tremadocian *Ceratopyge* Limestone of Gamlebyen, Oslo, Norway.

Diagnosis: Large isopygous trilobites of low convexity. Glabella convex, anteriorly rounded, with three pairs of lateral glabellar furrows; posterior pair being forked adaxially, none reaching the axial furrow. Frontal area 0.3 to 0.5 length of cranidium, together with anterior parts of fixed cheeks forming an extensive flat anterior area. Palpebral lobes of medium to large size, at or behind midlength of glabella. Fixed cheeks approximately half glabellar width at level of midlength of palpebral lobe. Posterior cephalic limb very wide and short. Pygidium with long, narrow axis of at least seven or eight rings. Pleural furrow curved posteriorly, becoming almost exsagittal posteriorly. Border with relatively narrow semielliptical excavation so that the margin on either side of it is extended into a strong spine.

Remarks: Affinities of the group of genera to which this genus belong were discussed by Kobayashi (1936, 1960) and by Henningsmoen (1959). As mentioned above the several groups of genera having spinose pygidia, with which affinities for the Dikelocephalinidae have been inferred, are homeomorphous forms and the true affinities of *Dikelocephalina* will only be arrived at by careful plotting of phylogenies at the species level. The rarity of *Dikelocephalina* in all its known occurrences suggests that plotting of such phylogenies will not be possible for some time but the Dikelocephalidae seems the family most likely to contain the ancestral stock.

The posterior pygidial spines are the most distinctive feature of the genus and their absence from any described species or the inability to observe the morphology of that part of the exoskeleton (e.g. for *D. parva* Kobayashi, 1960 and *D. conica* Kobayashi, 1960) must throw doubt on assignment to the genus. Another genus with similar posterior pygidial border morphology is *Asaphelina* Bergeron 1889, the type species of which was originally included in *Dikelocephalina* by Brøgger (1896). However, that genus is referred to the *Taihungshaniidae* (Courtessole *et al.*,

1981), which family is distinguished by the asaphoid glabella and pygidial pleural furrows being transverse or almost so; in *Taihungshania* itself, the pleural furrows are transverse in juvenile individuals so indicating its asaphoid affinities—their posterior sweep in adults is a secondary development. The posterior spines may reasonably be considered homeomorphous.

Within the family the position of the posterior spines distinguishes *Dikelocephalina* from all other genera.

Age and Distribution: Late Tremadoc; Norway, Sweden, Wales, South Korea, Tasmania.

***Dikelocephalina asiatica* Kobayashi, 1934**

Plate 8, figures 1-8

1934 *Dikelocephalina asiatica* Kobayashi, p. 563, pl. 6, figs 1-3.

1934 *Dikelocephalina kanaegata* Kobayashi, p. 564, pl. 6, figs 4, 5.

1980 *Dikelocephalina* sp. nov.; Stait & Laurie, p. 205, fig. 3, appendix 1.

Holotype (by original designation): Cranidium figured by Kobayashi (1934, pl. 6, fig. 2) from the *Clarkella* Zone (Late Tremadoc) at Saishori, South Korea.

Material: Apart from the figured material of Kobayashi the specimens assigned to this species are all from Faunal Assemblage No. 3 of Stait and Laurie on the Gordon Road Section and are numbered UTGD95978-95982, 96689, 122552, 122553.

Description of Tasmanian material: Cranidium of low convexity except for broadly convex glabella; glabella tapering gently forward to rounded anterior, with three pairs of lateral glabellar furrows adjacent to but separated from the axial furrow, furrow 1p bifurcate adaxially, elongate transversely, running very slightly to the posterior adaxially, not very deep, and with very gentle sides, its anterior branch shorter and less elongate and running forward adaxially; furrows 2p and 3p rounded pits very close to the axial furrow; 3p being just behind junction of eye ridge and axial furrow; occipital furrow well impressed, with deeper short wide apodemal pits reaching the axial furrow, medially shallowing and curving slightly forward; occipital ring of approximately

uniform length, with prominent median tubercle near midlength, with transverse posterior margin; extremely weak development of alae on one specimen (Pl. 8, fig. 7); preglabellar length 0.3 of cephalic length; anterior border furrow very vaguely apparent just forward of the midlength of the preglabellar length; all area in front of glabella flat; fixed cheeks narrow and flat; palpebral lobes prominent, with semicircular outer margin, with anterior end much closer to glabella than posterior end, sloping up abaxially; palpebral furrow not well impressed but nevertheless distinct, parallel to outer margin of lobe medially but swinging around both ends of lobe to facial suture; facial suture running forward from palpebral lobe in a broad curve but the palpebral lobe extends laterally beyond widest extent of anterior part of facial suture; posteriorly, facial suture running transversely out for 0.75 of basal glabellar width before curving sharply posteriorly to the margin; posterior cephalic limb wide and short, with uniform posterior border furrow running across its anterior part to the facial suture before the suture curves back; posterior border of uniform length, convex in lateral profile and downturned abaxially, with prominent gently curved terrace lines running mainly in the exsagittal direction; posterior margin transverse adaxially but curving slightly back abaxially.

Pygidium of low convexity, with axis standing only slightly above pleurae in anterior profile; length to width ratio unknown, articulating half-ring very short; axis of five well defined rings and a long poorly divided terminus that includes at least four more rings and the terminal piece which is at the inner edge of the doublure, quite wide anteriorly, tapering markedly in anterior half; rings of uniform length; wide, sharp, poorly defined, apodemal pits laterally in transaxial furrows visible only on internal moulds; axial furrow evident only as a change of slope and change of direction of furrows; pleural areas crossed by five pairs of well impressed pleural furrows becoming more exsagittal in direction, closer together and shallower towards the posterior; pleural furrows extend almost to the margin, shallowing markedly to nothing abaxial to the inner margin of the doublure; border not clearly

defined but a fairly wide flat marginal area that tapers forward is weakly defined by change of slope from pleural areas and ends of pleural furrows; posteriorly is a long but narrow excavation in the border with, as a consequence, a pair of sharp marginal spines beside it; border raised up to the margin of this excavation; on the border and possibly over the whole pleural area are very faint, irregular transverse terrace lines most numerous at the margin decreasing in number adaxially; doublure wide, very close beneath dorsal exoskeleton throughout being upturned near its mid-width to the pleural areas and being upturned with the dorsal exoskeleton around the posterior excavation, with strong terrace lines parallel to the margin over the entire width; inner edge of doublure with marked excavation posteromedial around the rear of the axis.

Remarks: The material illustrated by Kobayashi (1934) is relatively incomplete making comparison with new collections difficult. However, introduction of a new specific name when all observable features between the Korean and Tasmanian specimens are so clearly identical would be irresponsible. Although the margin of the two figured Korean cranidia (Kobayashi 1934, pl. 6, figs 2, 3) are very incomplete his dashed suggestions for their positions seem quite reasonable. However, his dashed outline for the holotype pygidium of *D. kanaegata* (Kobayashi, 1934, pl. 6, fig. 5) appears to have a right angle bend at the left anterolateral corner that is unlikely to be correct. The pygidium assigned to *D. asiatica* by (Kobayashi, 1934, pl. 6, figs 2, 3) are very incomplete his dashed suggestions for their positions have narrow raised pleural ribs separated by wide interspaces. If the external surface is correctly described then this specimen should be separated at least at the generic level from the associated cranidia. It is far more likely to be an internal mould of a juvenile specimen and its external morphology is likely to be more in line with the two pygidia assigned to *D. kanaegata*. As the two species occur together at Makkol, South Korea and after considering the states of preservation but without actually seeing the material we consider the two species of Kobayashi (1934) to be synonymous. Only the

structure and position of the palpebral lobe may appear to distinguish the Tasmanian species but the posterior course of the facial suture was interpreted by Kobayashi and may be in error. The holotype and one Tasmanian specimen show incipient alar development on one side only. One feature which does appear distinctive is the border region sloping down to the margin of the posterior excavation in Kobayashi's material (1934, pl. 6, fig. 4) whereas it is upturned in the Tasmanian specimens. This is considered to be intraspecific variation if it is real but the exoskeleton of this species is quite flexible and the difference may be due to preservational history. Further collection and study of material from the type locality is urgently needed to clarify this species. *Dikelokephalina asiatica* may be distinguished from the type species by its broader subtriangular rather than subquadrate pygidium, the closer position of the posterior spines, straight pleural furrows, very weak alae, anteriorly placed posterior border furrow on cranidium and less divergent more rounded facial suture in front of the palpebral lobe.

Asaphopsoides Hupe, 1955

Type species (by original designation): *Dicellosephalus* ? *villebruni* Bergeron, 1895 from the earliest Arenig of Montagne Noire, southern France.

Diagnosis: Dikelokephalinid with prelabellar length 0.3 or more of cephalic length; strong, wide, diagonally directed, linear apodemes in prelabellar furrow. Pygidial axis may contain 6 to 16 rings; pleural furrows swept backwards with posterior pleural furrows at very low angle to sagittal line; pygidial border moderately to very wide, without border furrow but with at least a pair of variably sized, prominent, flat spines placed relatively widely apart at posterolateral corners.

Species content of genus: *A. villebruni* type species. See Thorai, 1935 and Courtessole *et al.*, 1981.

Dikelosephalus florentinensis Etheridge, 1905 (Early Arenig; Tasmania) see below.

[= *Asaphopsis juneensis* Kobayashi, 1940a and *A. (?) gracicostatus* Kobayashi, 1940]

Asaphopsis nakamurai Kobayashi, 1936 (Early Ordovician; Doten, South Korea).

Asaphus elegantulus Gortani, 1934 (Early Ordovician; Chisil Pass, Karakorum).

Ogygites (?) annamensis Mansuy, 1920 (Early Arenig; Dong-san, North Vietnam).

Taihungshania welleri Sheng, 1934 and *Taihungshania welleri* var. *brevica* Sheng, 1934 (Tremadoc; Chekiang, China).

Asaphopsis granulatus Hsu, 1948, *A. planispiniger* Hsu, 1948, *A. angustigenatus* Hsu, 1948, *A. immanis* Hsu, 1948, *Temnoura grandispinifer* Hsu, 1948, and *Temnoura alata* Hsu, 1948 all from the Late Tremadoc or Early Arenig of western Hupeh, China.

Asaphopsis semicircularis Lu, 1975, *A. angulatus* Lu, 1975, *A. (?) abnormis* Lu, 1975, and *A. yaokoutzeensis* Lu, 1975, all from the Tremadoc or earliest Arenig of western Hupeh or southern Sichuan.

Asaphopsis wuchuanensis Yin in Yin & Li, 1978 (Tremadoc; Guizhou, China)

Asaphopsis yinjiangensis Yin in Yin & Li, 1978 (Tremadoc; Guizhou, China)

Asaphopsis sanchaqtensis Lu in Zhou *et al.*, 1978 (Tremadoc; southern China)

Asaphopsis latilimbatus Lu in Lu *et al.*, 1976 (Tremadoc; southern China)

Asaphopsis hanyuanensis Li, 1978 (Tremadoc; Sichuan, China)

Asaphopsis yanjinensis Li, 1978 (Tremadoc; Sichuan, China)

Asaphopsis ovoideus Xia, 1978 (Tremadoc; Hupeh, China)

Asaphopsis budabnensis Balashova, 1966 (Early Ordovician; Russian Platform)

Discussion: *Asaphopsoides* was erected to separate *Dicellosephalus* ? *villebruni* from *Asaphopsis* Mansuy, 1920 where it had previously been placed (Kobayashi, 1936, 1940). In doing so Hupe (1955) quoted features of the cranidium as generic taxobases. He, therefore, did not have the type species of *Asaphopsis* in mind as *A. jacobii* is known only from fragmentary pygidia and thoracic segments (Mansuy, 1920, pl. 1, fig. 7a-g). Although the concept of *Asaphopsis* has for almost 40 years rested upon Kobayashi's species *A. nakamurai* it is essential that Mansuy's (1920) type species be reappraised for a stricter generic basis. Of the pygidia figured by Mansuy only one (1920, pl. 1, fig. 7a) clearly shows the marginal spine and should be considered the lectotype. Both this and the other interpretable specimen (Mansuy, 1920, pl. 1, fig. 7b) have their pleural furrows running transversely near the anterior and at only a small angle (less than 20°) to the transverse line posteriorly. This feature alone suggests that the type is not congeneric with any other species so far referred to *Asaphopsis*. This type of pleural structure is much more reminiscent of asaphoid trilobites (e.g. *Asaphellina* of the Taihungshaniidae). The marginal spines of the Taihungshaniidae

and Dikelocephalinidae probably developed homeomorphously. The distinction is most evident in glabellar features of the cranidium but even in the pygidium, the Taihungshaniidae have much more transverse pleural furrows in adult *Asaphellina* Bergeron, 1889 (see Courtessole *et al.*, 1981, pl. 7, figs 1, 3, 6) and in juvenile *Taihungshania* Sun, 1931 (see Courtessole *et al.*, 1981, pl. 5, figs 1-6, 8, 9). Taking these data into account *Asaphopsis* should be restricted to *A. jacobi* and probably *A. reedi* which may be synonymous with the type species and that genus should be removed to a tentative placement in the Taihungshaniidae pending collection of cephalons of the type species.

The glabellar features of *Asaphopsoides villebruni* are illustrated by Thorl (1935, pl. 23, figs 5, 6) and Courtessole *et al.* (1981, pl. 4, fig. 5); the latter authors point out that they have been incorrectly illustrated in general textbooks. Certainly the illustration in the *Treatise* (Harrington *et al.*, 1959, fig. 268-6a) is highly inaccurate. However, the illustration of Courtessole *et al.* (1981) is not identical with the figures offered by Thorl (1935, pl. 23, figs 5, 6) and it may very well be that the bulge in the side of the glabella adjacent to the prominent pit in the glabella (presumably furrow 2° of Courtessole *et al.* 1981, p. 21) is an artefact of compression in the sediment. There is indication from many of the illustrated specimens of this genus (e.g. Lu, 1975, pls 26, 27) that the exoskeleton was very thin and had a certain amount of flexibility so generic taxobases should not be cited as such detailed features. Variations in the shape, size and position of lateral glabellar furrows should be used at present only as species taxobases in this trilobite family. As significant features listed in the diagnosis are remarkably uniform, where observed, through the species listed above, the many species previously referred to *Asaphopsis* should now be referred to *Asaphopsoides*. The long preglabellar part of the cephalon, marked linear apodemes in preglabellar furrow, posteriorly swung pygidial pleural furrows, and fairly widely separated marginal spines appear to be the most significant generic taxobases. The single pygidium upon which is based

Dainellicauda Kobayashi, 1960 is also referred to *Asaphopsoides* as none of the features mentioned as diagnostic by Kobayashi (1936, p. 177; 1960, p. 253) are valid. His indication that the marginal spine arises from the first pygidial segment is not substantiated and the position of the abaxial end of the fourth pleural furrow, aiming at the margin just behind the base of the spine, is identical with that in several Chinese species of *Asaphopsoides* as well as *A. florentinensis*. *Dainellicauda* is a junior subjective synonym of *Asaphopsoides*.

Distribution and age: Late Tremadoc to Arenig of China; Early Arenig of France and Tasmania; Early Ordovician of Russia, South Korea, northern Vietnam and Pakistan.

***Asaphopsoides florentinensis* (Etheridge, 1905)**
Plate 2, figure 15; plate 9, figures 1-11; plate 10, figures 1-10

- 1905 *Dikelocephalus florentinensis* Etheridge, p. 24, pl. 10, fig. 4.
- 1914 *Dikelocephalina florentinensis* (Etheridge); Walcott, p. 350.
- 1936 *Taihungshania florentinensis* (Etheridge); Kobayashi, p. 179, pl. 20, fig. 16 (not fig. 15).
- 1936 *Asaphopsis florentinensis* (Etheridge); Kobayashi, p. 177, pl. 21, fig. 5.
- 1940 *Asaphopsis juneensis* Kobayashi, p. 64, pl. 11, figs 6-9.
- 1940 *Asaphopsis* (?) *gracilicostatus* Kobayashi, p. 65, pl. 11, fig. 10.
- 1974 "*Asaphopsis*" *juneensis* Kobayashi; Corbett & Banks, pl. 1, figs 14, 17, 18, 22, 23, 24; pl. 2, fig. 9.
- 1980 *Asaphopsis juneensis* Kobayashi; Stait & Laurie, p. 207.
- 1980 *Asaphopsis* sp. nov. Stait & Laurie, p. 207.

Holotype (by monotypy): AMF9282 a damaged and distorted pygidium from the Florentine Valley, southwestern Tasmania at a site near 'The Gap' (*vide* Corbett & Banks, 1974, p. 219).

Other material: More than fifty dissociated exoskeletal parts from 'The Gap' and from the Gordon Road Section. *Asaphopsis* sp. nov. and *A. juneensis* of Stait and Laurie (1980, fig. 3) and *A. juneensis* of Corbett and Banks (1974) were available (including UTGD80995, 80999, 81001, 81019, 81086, 96022, 96036, 96038, 96650, 96652, 98053, 98060, 98075, 122525, 122555-122561).

Diagnosis: Member of *Asaphopsoides* with parallel-sided to anteriorly tapering glabella

ternal mould with its convexity reversed during or after burial; such specimens are known in the available collection. Therefore the short pleural ribs are actually moulds of the pleural furrows and this is clear on the proximal doublure. Although one of his pygidia shows at least 9 pygidial axial rings this is a notoriously variable feature likely to be greater on internal moulds. It seems most likely that, given the ubiquitous tectonic deformation of specimens from the Florentine Valley Formation, *Asaphopoides* is represented in that formation by a single species. Certainly material available to us does not indicate otherwise.

Of foreign species *A. villebruni* is very close to the Tasmanian species but its preglabellar length appears (based on only two specimens figured by Thorpe in 1935) to be less, its palpebral lobes are proportionally longer and the pygidium has different transaxial furrows and very slightly longer marginal spines. However, these are minor differences that may ultimately prove to be of less than specific significance. *A. nakamurai* has tiny palpebral lobes situated well forward and the pygidial marginal spines are situated well back (i.e. the fourth pleural furrow, if continued, reaches the margin well in front of the spine). *A. annamensis* and *A. elegantulus* are too poorly known for comparison. Of Chinese species, almost all are clearly distinguished by their long slender marginal spines but *A. planispiniger* appears very close to *A. florentinensis* although the rear of the hypostome appears to have a slightly different configuration (Lu, 1975, pl. 26, fig. 20), pygidial pleural furrows extend across the border almost to the margin and the third rather than the fourth pleural furrow reaches the margin just behind the marginal spine (Lu in Lu *et al.*, 1965, pl. 111, fig. 14).

A number of juvenile cranidia and pygidia are available but show no significant differences from the adults except perhaps they have more relief, more elevated palpebral lobes and furrows, and in at least one specimen the fifth pleural furrow reaches the margin just behind the spine. This may be interpreted as the final meraspid stage; as one more thoracic segment moves out into the thorax so the fourth furrow will be adjacent to the spine.

Family HARPEDIDAE Hawle & Corda, 1847

Scotoharpes Lamont, 1948

Type species (by original designation): *Scotoharpes domina* Lamont, 1948 from the Upper Llandovery of Scotland.

Remarks: Despite the brief original description of the type species a detailed appraisal of that species, including illustration of the holotype is now available (Norford, 1973). Norford also recognised *Selenoharpes* Whittington, 1950 and *Aristoharpes* Whittington, 1950 as junior subjective synonyms of *Scotoharpes*. Although efforts to recognise stratigraphically useful generic morphotypes are laudable the relatively large collections of the Tasmanian species and of *Australoharpes* (Jell, 1985) suggesting that cephalic shape and development of alae are variable with growth make the generic concepts of a number of harpedid genera appear to be too typological in their definition. Accordingly we accept Norford's synonymy and assign the new Tasmanian species to *Scotoharpes* because of the close comparison in all observable features. The extent of the girder along the prolongation and occurrence of slightly coarser pits along the girder and the upper and lower rims are important features in common.

Scotoharpes lauriei sp. nov.

Plate 11, figures 4-14

Etymology: The species is named for John Laurie who was involved in the original biostratigraphic study of the Gordon River Road section and helped collect much of the material.

Material: Holotype UTGD121586, paratypes UTGD95922, 96007, 96008, 96010, 121496, and 122566-122569 all from NMVPL1602.

Diagnosis: Member of *Scotoharpes* with only very faint 1p furrow evident on glabella, an occipital node, very faint alae evident as extremely weak depressions or not evident at all, with short posteriorly directed spine on posterior of prolongation.

Description: Cephalon subcircular to subovate, moderately convex. Glabella narrow (less than 20% of cephalic width), and approximately half cephalic length (without prolongation),

broadly rounded anteriorly; palpebral lobes of moderate size, highly arcuate laterally, situated at or behind glabellar midlength; pygidium with narrow tapering axis of at least seven rings and a long terminal piece which may represent several more rings; marginal spines small, inconspicuous, widely separated; posterior margin broadly rounded.

Description: Up to very large size (pygidia 80 mm wide known). Cranidia relatively flat except for convex glabella; glabella with lateral margins parallel-sided to slightly converging forward; glabellar anterior broadly rounded with deeper wide apodemal pits (fossulae) in the preglabellar furrow laterally making those parts of the furrow quite straight; three pairs of well impressed lateral glabellar furrows on the steep lateral slope of the glabella, close to but not confluent with axial furrow; occipital furrow distinct but shallow; occipital ring of uniform length, with low median node at midlength; preglabellar part of cranidium (considered to be greatly expanded anterior border as doublure extends back to front of glabella) flat with faint epiborder furrow evident on some individuals, with transverse ridge evident at inner margin of doublure (possibly compaction feature) on other specimens; palpebral lobe prominently bulging laterally, slightly raised above rest of cheek, relatively close to glabella; palpebral furrow not parallel to lateral margin of lobe but rather almost straight, nearly exsagittal diverging slightly posteriorly and rather shallow; facial sutures anterior to eye diverging forward to converge again forward of the midlength of border in well rounded arch to meet the margin apparently not far from midline; posterior cephalic limb very wide, with long posterior border elongating laterally, well impressed transverse border furrow shallowing and shortening laterally and short band of fixed cheek before facial suture that is transverse from rear of palpebral lobe until it curves sharply to the posterior where it meets margin at right angles.

Hypostome large, more or less equidimensional median body markedly convex at anterior where it has almost vertical slope in the midline; border furrow very short anteriorly,

wider and deeper laterally, running prominently into well-impressed middle furrow, almost imperceptible across shoulder past short posterior lobe of median body, well impressed posterolaterally but shallowing posteromedially; border short and continuous across midline anteriorly, expanding laterally into large flat triangular wings, contracting to a narrow ridge near midlength of anterior lobe of median body, expanding again posteriorly into a flat expansive shoulder approximately as wide as the anterior wing and tapering strongly into a short rim-like posterior border.

Pygidium relatively flat with only real convexity in axis, pleural areas sloping gently to margin with no border furrow impressed; axis straight-sided, tapering posteriorly, with well rounded posterior at inner edge of doublure, a considerable distance from margin, with variable (i.e. between specimens and between internal and external surfaces) number of rings visible (6-12 in available material); transaxial furrows straight, weakly impressed but distinct becoming less so posteriorly, with only very weak apodemal depressions laterally away from the axial furrow; pleural area with at least 7 (sometimes a weak eighth) pleural furrows that recurve posteriorly approaching the border and are almost exsagittal posteriorly; fourth pleural furrow if continued in regular curve meets margin just behind the spine; border wide, not crossed by pleural furrows (may be an artefact of flattening after burial); margin smoothly rounded, with pair of short flat or weakly convex posterolateral spines, broadly rounded and sometimes with a pair of very wide short bulges symmetrically placed about the midline between the spines (pl. 10, figs 4, 7); doublure quite wide and ornamented with continuous parallel terrace lines most numerous near the inner edge.

Remarks: Every specimen observed is distorted to some degree and almost all previous observations have been made on internal moulds. Each of the features quoted by Kobayashi (1940) as distinguishing his Tasmanian specimen from Etheridge's (1905) is greatly influenced by one of these factors. Kobayashi's *A. ? gracilicostatus* (1940, pl. 11, fig. 10) is almost certainly an ex-

moderately convex, tapering gently forward to narrowly rounded anterior, with extremely faint 1p furrow the only glabellar furrow present. Axial furrow well impressed laterally but little more than a change of slope in front of the glabella, also shallower posteriorly just in front of the border furrow where alae are situated. Occipital furrow shallow with gentle anterior and posterior slopes into it. Occipital ring of uniform length, rising to the highest point at the posterior, with high median tubercle standing like a post on the anterior of the ring. Alae small and very subtly depressed if at all evident. Eye tubercles just behind anterior of glabella, large and round, elevated almost to height of glabellar rear; eye ridge transverse, straight, long and low in section, joining axial furrow but not crossing it just behind glabellar anterior; weak fossular depression in front of eye ridge. Preglabellar field and anterior cheek roll about equal in length, together sloping very gently down to the brim, cheek roll of uniform width except posterolaterally where it is extended in both directions along the posterior margin into a triangular area. Girder prominent as a ventrally projecting ridge, meeting inner rim at about one-third of the distance from the posterior of the occipital ring to the tip of the brim prolongation, represented on upper lamella by broad caecum from which issue smaller diameter radial caeca that are separated immediately against the girder by pits of the same diameter as those elsewhere. Brim flat to gently concave, covered by radially arranged anastomosing caecal network, caeca separated by pits of fairly uniform size, pits against rim also of same size; brim prolongation tapers posteriorly as the outer rim curves adaxially towards the posterior, with spine of circular section on posterior extremity, including spine as long as axial length of cephalon.

Thorax of 14 or more segments, tapering posteriorly; axis tapering markedly towards the posterior, just slightly narrower than width of each pleuron.

Pygidium transverse, of low convexity; axis tapering markedly, of 7 rings and minute terminus situated some distance in front of border furrow; axial furrow not impressed, only a change of slope; pleural areas smooth except

for anterior border furrow, distinct articulating facet developed; border furrow broad and shallow but distinct; border very narrow, tapering posteriorly, horizontal.

Remarks: *Scotoharpes lauriei* may be distinguished from *S. domina* by the shape of its prolongation, and its weak alar development; from *S. latior* (Poulsen, 1934) by its glabellar shape, weak alae and prominent girder; from *S. vetustus* Zhou & Zhang, 1978 by the prominent alae of that species although that species is too poorly known for useful comparison; it differs from all other species of the genus in its weaker alae but resembles juvenile specimens of *S. loma* (Lane, 1972) (see Norford, 1973, pl. 3, fig. 6) in this as well as most other features. This last resemblance indicates its ancestral relationship to Lane's Silurian species.

Family PILEKIIDAE Sdzuy, 1955

Although Lane (1971) advocated inclusion of this group as a subfamily of the Cheiruridae we prefer to retain it as a separate family mainly on the basis of the type of thoracic pleural furrows and on the commonly four segments in the pygidium. This arrangement is also favoured to accommodate a number of phylogenetic possibilities that will be discussed in another paper (Jell, 1985).

Pilekiidae gen. et sp. nov.

Plate 12, figures 1-4

Material: Two cranidia (UTGD122570 and 122571) and two pygidia (UTGD122572 and 122573) all external moulds from NMVPL1601.

Description: Glabella almost as wide as long; tapering only slightly forward from widest point at furrow 1p, with broadly rounded anterior, highly convex in anterior profile, with three pairs of lateral glabellar furrows; glabellar furrows wide, slit-like, almost transverse or directed back adaxially, dividing glabella into lobes of equal length except for the slightly longer frontal lobe; axial furrow well impressed, narrow, continuing forward as the preglabellar furrow without change; preglab-

bellar field absent; anterior border extremely short, convex, like a rope running across the front of the glabella, elongate a little towards facial suture, curved back strongly around anterolateral corners of glabella; palpebral lobe broad, short, at small angle to exsagittal line, meeting axial furrow just behind level of furrow 3p, curving evenly back fairly close to the axis to near the level of furrow 1p, convex and uniform in section throughout; palpebral furrow well impressed, parallel to lobe and curving out around posterior of palpebral lobe; fixigena behind palpebral lobe as wide as base of glabella, but quite narrow between palpebral lobes, sloping down strongly abaxially, with pitted ornament; facial suture proparian very short and curving adaxially in front of palpebral lobe, running transversely behind palpebral lobe to meet lateral margin at about level of furrow 1p; ventral sutures unknown; posterior border convex both in posterior profile and in section with the latter flattening out laterally, becoming elongate laterally and extended into apparently short (full extent not evident on only available specimen) fixigenal spine at the genal angle; posterior border furrow well impressed, short, of uniform cross-section laterally to beyond the genal angle, similar to the glabellar furrows in cross-section.

Hypostome, rostral plate and thorax not known.

Pygidium small, transverse; axis of four rings and small semicircular terminus reaching posterior margin; rings slightly longer towards posterior, of uniform length, separated by well-impressed transaxial furrows becoming shallower towards the posterior; pleural areas crossed by well-impressed pleural and interpleural furrows; interpleural furrows curved posteriorly and deeper towards margin; pleural furrows shallowing towards margin and not curved; posterior pleural band extended into short blunt free spine on each segment, turning sharply posteriorly at the base of the spine; fourth segment with very weak pleural furrows, with its short spines enclosing the axial terminus laterally; all marginal spines directed posteriorly. Surface of cranidium and pygidium (except in furrows) covered with fine widely-spaced granules.

Remarks: This species is closely related to *Pilekia* but we consider that it will be found to represent a separate genus based on its less bulbous 1p glabellar furrow, its lack of a strong genal or fixigenal spine, the tiny semicircular pygidial axial terminus, and the transverse pleural furrows in front of posterior pleural bands that turn sharply back at the base of the marginal spines. The combination of these features separates it from all those assigned to either *Pilekia* Barton, 1915 or *Parapilekia* Kobayashi, 1934.

***Pilekia* Barton, 1915**

Type species (by original designation): *Cheirurus apollo* Billings, 1860.

***Pilekia* sp. nov.**

Plate 12, figures 8-12

Material: UTGD95987, 95989, 96664, 122577, 122578 all from NMVPL1600.

Description: Glabella with widest point near anterior of lobe 1p or rear of lobe 2p, with well rounded anterior, with well impressed almost transverse occipital furrow becoming slightly longer medially and with lateral parts running forward from axial furrow, with occipital ring only marginally longer than occipital furrow and shorter laterally with convex lateral profile rather than the flatter profile medially, with ornament of coarse tubercles except in furrows; lateral glabellar furrows well-impressed, weakly convex forward, becoming shallower shorter and directed posteriorly towards the axis, with long flat bottoms near axial furrow and steep almost vertical sides, with furrow 1p reaching back almost to the occipital furrow and isolating a large prominent 1p lobe; lobes becoming progressively shorter forward with anterior lobe being quite short and subrhombic in shape with arcuate anterior; anterior border furrow short and deep; anterior border short, rising strongly forward, of uniform length on cranidium; eye ridge running out and slightly back from axial furrow near level of midlength of lobe 3p, straight, convex in section; fixed cheeks wide, subtriangular, with strong reticulate ornament of caecal ridges separated by prominent pits and bearing sparsely scattered tubercles on top of the ridges; palpebral lobe

relatively small, curved posteriorly, defined by prominent furrow that extends along rear of eye ridge; posterior border furrow well-impressed, becoming slightly longer abaxially, continuing around genal angle as slightly narrower lateral furrow, beginning in axial furrow at occipital furrow not at posterior margin; posterior border short near axial furrow, becoming longer and flatter laterally, bearing strong posterolaterally directed fixigenal spine (Pl. 12, fig. 8b) some distance adaxial to the genal angle; course of facial suture not clear on any specimen.

Librigena, rostrum, hypostome, and thorax unknown.

Pygidium transverse to subsemicircular, with convex axis standing above pleural areas; axis of four rings and terminus; each ring of uniform length, fourth only slightly shorter than first; terminus almost twice as long as a ring, considerably narrower than fourth ring, reaching margin posteriorly, descending steeply to posterior; pleural area with well impressed pleural and interpleural furrows, tapering posteriorly, with pleural area of fourth segment absent; pleural furrows beginning near anterior of segment at axial furrow, running transversely in two anterior segments then curving a little to the posterior to finish in line with the anterior part of the marginal spine, running transversely across narrow third pleura towards the anterior part of the marginal spine; interpleural furrows transverse for most of their course before turning slightly posteriorly abaxially and meeting margin between marginal spines; four pairs of evenly spaced marginal spines present; first and second pairs of marginal spines tapering evenly from base but quite long (about as long as pygidium), circular to slightly flattened in section; third marginal spine with parallel sides through the part preserved and inferred to be considerably longer than others; fourth marginal spine shortest, almost exsagittal, widely separated from axial terminus and hence from matching spine on other side; ornament on pygidium of fine sparsely scattered tubercles.

Remarks: The species' taxobases are the different sized pygidial marginal spine and the fixigenal spine situated adaxially from the genal

angle. There is not sufficient material available to propose a new specific name but its novelty is not in doubt. Assignment to *Pilekia* is based in particular, on the enlarged 1p lobes and the greatest width of the glabella being near the anterior of lobe 1p but all other features are consistent with this assignment. Relative sizes of pygidial spines seem to separate this material from any described species of *Pilekia*.

Family PLIOMERIDAE Raymond, 1913

Whittington (1961) removed the pilekiids from this family and noted that division of the remaining taxa into subfamilies was unwarranted. Nothing has happened during the intervening years to alter that view.

Protopliomerops Kobayashi, 1934

Type species (by original designation): *Protopliomerops seisonensis* Kobayashi, 1934 from the late Tremadoc *Protopliomerops* Zone at Saisho-ri, South Korea (Tomkol Shale of Kobayashi, 1966).

Remarks: This genus was diagnosed by Kobayashi (1934) and extensively discussed by Ross (1951) with additions to the diagnosis. The species described below adds only an articulated thorax to the generic concept so further discussion is unnecessary.

Protopliomerops hamaxitus sp. nov

Plate 13, figures 1-14

1974 *Cybelopsis* sp. Corbett & Banks, pl. 2, figs 15, 16.

1980 ?*Pliomerina subquadrata* (Kobayashi); Stait & Laurie, fig. 3, appendix 1.

Etymology: From Greek *hamaxitos* meaning highway; referring to type locality on a highway.

Material: Holotype UTGD122585, paratypes UTGD95886, 95999, 96003, 96625, 121491, and 122579-122587 all from NMVPL1602. Numerous other specimens from each of the localities indicated in the introduction were also available.

Diagnosis: Member of *Protopliomerops* with axial furrows diverging very weakly forward; lateral glabellar furrows slit-like, 3p reaching axial furrow at anterolateral corner of glabella; occipital furrow with strong anterior curve medially over the axis; occipital ring without

node; palpebral lobe not markedly expanded, long extending back to level of 1p furrow; genal spines short; ornament over whole cephalon of fine pustules, cheek areas with numerous pits between a network of ridges. Thorax of 12 segments; pleural tips spinose, curved slightly posteriorly. Pygidium with axis tapering strongly posteriorly, of five rings and triangular terminus drawn out to reach posterior margin; five pairs of marginal spines with tips well apart; anterior border very short.

Description: Small trilobite, tapering posteriorly throughout the axis and in the lateral spinose margin. Cephalon semicircular, moderately convex, proparian; glabella approximately 0.33 of cephalic width, widest anteriorly, with broadly rounded anterior, straight sides, and three pairs of lateral glabellar furrows; 1p furrow longest of three, angling backwards towards axis; 3p furrow most oblique, meeting axial furrow at or in front of the anterolateral corner of the glabella; occipital furrow swinging strongly forward near adaxial end of furrow 1p, in an even curve across axis, deep, with U-shaped cross-section; occipital ring with slightly oblique posterior margin laterally becoming transverse medially, without node, elongate medially; anterior border short and convex medially, slightly flatter and longer lateral to glabella; anterior border furrow short and slit-like medially, elongate lateral to the glabella in front of the palpebral ridge; palpebral ridge narrow but relatively long, continuing unchanged into the palpebral lobe; palpebral lobe not greatly expanded, swung back strongly to be almost exsagittal, almost reaching back to 1p furrow; facial suture running forward from palpebral lobe close to axial furrow only a short distance to margin, running almost transversely behind eye but curving back distally to meet the margin just in front of the genal angle; interocular cheeks very narrow; posterior border becoming elongate near genal angle, drawn out at genal angle into short spine that extends only slightly laterally but strongly posteriorly. Fixigena triangular, with well-impressed border furrow, convex border and high curved doublure. Hypostome with prominent convex median body occupying most of its area; anterior wings wide, tapering laterally,

flattened in a plane at approximately 60° to the plane of the main body of the hypostome; border furrows well impressed running into distinct median furrows very close to posterior; posterior lobe short but longer than posterior border, isolated completely by median furrows; shoulder only slightly expanded; entire surface covered with fine pustulose ornament.

Thorax of 12 segments; axis short, highly convex with very short articulating half ring, with strong bulbous apodemes laterally in articulating furrow; pleurae with very short anterior pleural bands not evident on most specimens (as they are concealed by the next anterior segment deep within the pleural furrow); pleural furrows well impressed, dividing the short low anterior pleural band from the long high posterior pleural band that occupies almost all the exposed part of the pleura; pleural extremities are long, hollow, free spines that taper gradually and curve posteriorly from the articulating line (clearly evident on internal moulds (Pl. 10, fig. 10)); articulating lines converging posteriorly, with narrow distinct doublure beneath.

Pygidium semicircular, weakly convex; axis of five rings of equal length, becoming progressively narrower posteriorly and a terminus; terminus triangular, longer than wide, reaching posterior margin, much narrower than last axial ring, enclosed laterally by fifth pleurae, separated from fifth pleurae by very shallow furrows; transaxial furrows deep, becoming shallower and shorter posteriorly, weakly convex anteriorly; articulating half ring and anterior border extremely short and low, latter of uniform length; anterior pleural band visible low in first pleural furrow of some specimens; pleural furrows very deep, more posterior ones curving posteriorly, with fifth pair exsagittal to converging; posterior pleural band dominating pleural areas as high ridges extending beyond margin as large spines; marginal spines finishing with tips of successive spines well apart and sharply pointed, in five pairs of which second and third seem longest; all raised areas covered by pustulose ornament but furrows smooth.

Remarks: The ornament, occipital furrow, lack of occipital node, widely spaced tips of the

pygidial marginal spines and longer palpebral lobes distinguish *P. hamaxitus* from the type species. *Protopliomerops granulatus* and *P. punctatus* both from Korea (Kobayashi, 1934, pl. 7, figs 2-5) may be distinguished by their pygidia having six pairs of marginal spines. The three species assigned to *Protopliomerops* by Ross (1951) from Utah may be distinguished by their expanded palpebral lobes and different combinations of other features in the pygidium. *Protopliomerops rossi* Harrington & Leanza, 1957 may be distinguished by its glabellar shape, and the widely separated fifth pair of pygidial marginal spines without the discrete triangular terminus between them. Glabellar shape varies in the five illustrated internal moulds of cranidia to the same extent as in the Gordon Road collections so this may not be a distinguishing feature. In members of this family morphology is so different depending on whether internal moulds or external surfaces are used that *P. rossi* may ultimately prove to be synonymous with *P. hamaxitus*. Features most distinctive of *P. hamaxitus* seem to be its lack of an occipital node, long palpebral lobes, five pairs of well spread pygidial marginal spines and almost no expression of anterior pleural bands in pleural areas.

A complete morphogeny is not available but one juvenile pygidium plus posterior thorax (Pl. 13, fig. 4) does give some insight into growth of that part of the exoskeleton.

***Protopliomerops* sp. cf. *P. punctatus*
Kobayashi, 1934**

Plate 11, figures 1-3; plate 12, figures 5-7

Material: Three cranidia (UTGD122562-122564) and three pygidia (UTGD122574-122576) all from a single block of shale at NMVPL1602.

Remarks: The comparison of this material with Kobayashi's species is based almost exclusively on the pygidium because the tiny fragment of a cranidium assigned by Kobayashi, could scarcely be considered to provide an adequate basis for comparison. The six pairs of pygidial spines, the way the pleural ribs are close together and the structure of the axis are all significant features that are shared by *P. punctatus* and this Tasmanian material. In fact there are no observable differences. Essential features of the cranidium are the almost isolated 1p glabellar lobes, the almost transverse glabellar furrows with 3p meeting the axial furrow behind the anterolateral corner of the glabella, the long palpebral lobe (or rather palpebro-ocular ridge), and short genal spine. These features do not compare with any known cranidia and certainly not with the short palpebral lobe of Kobayashi's *P. punctatus*. However, his representation does show transverse glabellar furrows with 3p behind the anterolateral glabellar corner. These cranidia may prove to have the features of *P. punctatus* when cranidia of that species are better known.

References

- ANGELIN, N. P., 1854. *Palaeontologica Scandinavica. Part 2. Academiae Regiae Scientiarum Suecanae*, 21-92.
- BANKS, M. R. & BURRETT, C. F., 1980. A preliminary Ordovician biostratigraphy of Tasmania. *J. geol. Soc. Aust.* 26: 363-375.
- BARTON, D. C., 1915. A revision of the Cheirurinae, with notes on their evolution. *Wash. Univ. Stud. scient. Ser.* 3: 101-152.
- BERG, R. R. & ROSS, R. J., 1959. Trilobites from the Peerless and Manitou Formations, Colorado. *J. Paleont.* 33: 106-119.
- BERGERON, J., 1889. *Etude geologique du Massif ancien situe au sud du plateau central*. These, Paris, 1-362.
- BERGERON, J., 1895. Notes paleontologiques. *Bull. soc. geol. France* 23: 465-484.
- BILLINGS, E., 1859. Description of some new species of trilobites from the lower and middle Silurian of Canada. *Can. Naturalist* 4: 367-383.
- BILLINGS, E., 1860. On some new species of fossils from the limestone near Point Levi opposite Quebec. *Can. Naturalist* 5: 301-324.
- BROGGER, W. C., 1896. Über die Verbreitung *Euloma-Niobe* Fauna (der Ceratopygenkalkfauna) in Europe. *Nyt Magazin for Naturvidenskaberne* 35: 16-24.
- CALLAWAY, C., 1877. On a new area of Upper Cambrian rocks in south Shropshire, with a description of a new fauna. *Quart. J. geol. Soc. Lond.* 33: 652-671.
- CHANG, W. T., 1949. Ordovician trilobites from Kaiping, Hebei and the Qaidam Basin. *Bull. Geol. Soc. China* 29: 110-125.
- CHUGAEVA, M. N. & APOLLONOV, M. K., 1982. The Cambrian-Ordovician boundary in the Batyrbaishai section, MALYI KARATAU RANGE, KAZAKHSTAN, USSR. In *The Cambrian-Ordovician boundary: sections, fossil distributions, and correlations*. M. G. Bassett & W. T. Dean, eds, National Museum of Wales, Geological Series, No. 3, Cardiff, 77-85.
- COOPER, R. A. & STEWART, I., 1979. The Tremadoc graptolite sequence of Lancefield, Victoria. *Palaeontology* 22: 767-797.

- CORBETT, K. D. & BANKS, M. R., 1974. Ordovician stratigraphy of the Florentine Synclinorium, south-west Tasmania. *Pap. Proc. R. Soc. Tasm.* 107: 207-238.
- COURTESSOULE, R., PILLET, J. & VIZCAINO, D., 1981. *Nouvelles données sur la biostratigraphie de l'Ordovicien inférieur de la Montagne Noire. Revision des Taihungshaniidae, de Megistaspis (Ekeraspis) et d'Asaphopoides (Trilobites)*. Memoire de la Societe des Etudes Scientifique de l'Aude, Carcassonne, 1-32.
- ENDO, R., 1935. Additional fossils from the Canadian and Ordovician rocks of the southern part of Manchoukuo. *Sci. Rep. Tohoku Imp. Univ.*, ser. 2: 16(4).
- ETHERIDGE, R. JR., 1905. Trilobite remains collected in the Florentine Valley, west Tasmania, by Mr T. Stephens, M.A. *Rec. Aust. Mus.* 5: 98-101.
- FORTEY, R. A. & PEEL, J. S., 1983. The anomalous bathyrid trilobite *Ceratopeltis* and its homeomorphs. *Spec. Pap. Paleont.* 30: 51-57.
- GOBBETT, D. J., 1960. A new species of trilobite from the lower Oslobreen Limestone. *Geol. Mag.* 107: 457-460.
- GORTANI, M., 1934. *Fossili Ordoviciani del Caracorum*. Spediziosi ital. De Filippi Nel l'Himalaya, Caracorum e Turkestan Cinese (1913-1914), ser. 2, vol. 5.
- HARRINGTON, H. J. & LEANZA, A. F., 1957. Ordovician trilobites of Argentina. *Spec. Publ. Univ. Kans. Dept. Geol.* 1: 1-276.
- HARRINGTON, H. J., MOORE, R. C. & STUBBLEFIELD, C. J., 1959. Morphological terms applied to Trilobita. In *Treatise on Invertebrate Palaeontology Part O. Arthropoda 1*, R. C. Moore, ed., Geol. Soc. Amer. & Univ. Kansas Press, Lawrence, Kansas, 117-126.
- HARRINGTON, H. J., et al., 1959. Systematic descriptions. In *Treatise on Invertebrate Palaeontology, Part O. Arthropoda 1*. R. C. Moore, ed., Geol. Soc. Amer. & Univ. Kansas Press, Lawrence, Kansas, 170-540.
- HENNINGSMOEN, G., 1959. Rare Tremadocian trilobites from Norway. *Norsk. geol. Tidskr.* 39: 153-174.
- HINTZE, L. J., 1953. Lower Ordovician trilobites from western Utah and eastern Nevada. *Bull. Utah geol. Miner. Surv.* 48: 1-249.
- HSU, S. C. & MA, C. T., 1948. The Ichang Formation and the Ichangian fauna. *Inst. Geol. Acad. Sinica* No. 8.
- HUPE, P., 1953. Classification des trilobites. *Annales Paleontologie* 39: 61-168.
- HUPE, P., 1955. Classification des trilobites. *Annales Paleontologie* 41: 91-325.
- JELL, P. A., 1985. Tremadoc trilobites of the Digger Island Formation, Waratah Bay, Victoria. *Mem. nat. Mus. Vict.* This volume.
- KOBAYASHI, T., 1934. The Cambro-Ordovician formations and faunas of South Chosen. *Palaeontology*. Part 2. Lower Ordovician faunas. *J. Fac. Sci. Tokyo Univ.* ser. 2, 3: 521-585.
- KOBAYASHI, T., 1935. On the *Kainella* fauna of the basal Ordovician age found in Argentina. *Jap. J. Geol. Geogr.* 12: 59-67.
- KOBAYASHI, T., 1936. Three contributions to the Cambro-Ordovician faunas. *Jap. J. Geol. Geogr.* 13: 163-184.
- KOBAYASHI, T., 1940. Lower Ordovician fossils from Junece, Tasmania. *Pap. Proc. R. Soc. Tasm.* 1939: 61-66.
- KOBAYASHI, T., 1955. The Ordovician fossils of the McKay Group in British Columbia, western Canada, with a note on the early Ordovician palaeogeography. *J. Fac. Sci. Tokyo Univ.* ser. 2, 9: 355-493.
- KOBAYASHI, T., 1960. The Cambro-Ordovician formations and faunas of South Korea, Part 6. *Palaeontology* 5. *J. Fac. Sci. Tokyo Univ.*, ser. 2, 12: 217-275.
- KOBAYASHI, T., 1966. The Cambro-Ordovician formations and faunas of South Korea. Part 10. Stratigraphy of the Chosen Group in Korea and south Manchuria. *J. Fac. Sci. Tokyo Univ.*, ser. 2, 16: 209-311.
- LAMONT, A., 1948. Scottish dragons. *Quarry Manager's Journal* 31: 531-535.
- LANE, P. D., 1971. *British Cheiruridae (Trilobita)*. *Palaeontological Society Monograph*, London, 95p.
- LANE, P. D., 1972. New trilobites from the Silurian of north-east Greenland, with a note on trilobite faunas in pure limestones. *Palaeontology* 15: 336-364.
- LAURIE, J. R., 1980. Early Ordovician orthide brachiopods from southern Tasmania. *Alcheringa* 4: 11-23.
- LEGG, D. P., 1978. Ordovician biostratigraphy of the Canning Basin, Western Australia. *Alcheringa* 2: 321-334.
- LEWIS, A. N., 1940. Geology of the Tyenna Valley. *Pap. Proc. R. Soc. Tasm.* 1939: 33-60.
- LI, SHEN-CHI, 1978. Trilobita. In *Atlas of the palaeontology of the southwest regions. Sichuan Volume. 1. Sinian to Devonian*. Sichuan Geological Bureau, ed., Geology Press, Peking, 179-283.
- LU, YAN-HAO, 1975. Ordovician trilobite faunas of central and southwestern China. *Palaeont. Sinica*, new series B, 11: 1-463. 1965.
- LU, YAN-HAO, CHANG, W. T., CHU, CHAO-LING, CHIEN, YI-YUAN & HSIANG, L. W., 1965. *Fossils of China. Chinese trilobites*. Science Press, Peking, 766 p.
- LU, YAN-HAO, CHU, CHAO-LING, CHIEN, YI-YUAN, ZHOU, ZHI-YI, CHEN, JUN-YUAN, LIU, CHENG-WU, YU, WEN, CHEN, XU & XU, HAN-KUI, 1976. Ordovician biostratigraphy and palaeozoogeography of China. *Mem. Nanjing Inst. Geol. Palaeont.* 7: 1-83, pls 1-14.
- MANSUY, H., 1920. Nouvelle contributions a l'Etude des faunas Palaeozoiques et Mesozoiques. *Mem. Ser. Geol. Indochine* 7(1): 6-21.
- MILLER, J. F., TAYLOR, M. E., SHITT, J. H., ETHINGTON, R. L., HINTZE, L. F. & TAYLOR, J. F., 1982. Potential Cambrian-Ordovician boundary stratotype sections in the western United States. In *The Cambrian-Ordovician boundary: sections, fossil distributions, and correlations*. M. G. Bassett & W. T. Dean, eds, National Museum of Wales, Geological Series No. 3, Cardiff, 155-180.
- NORFORD, B. S., 1973. Lower Silurian species of the trilobite *Scotoharpes* from Canada and northwestern Greenland. *Bull. geol. Surv. Can.* 222: 9-34.
- OWENS, R. M., FORTEY, R. A., COPE, J. C. W., RUSHTON, A. W. A. & BASSETT, M. G., 1982. Tremadoc faunas from the Carmarthen District, South Wales. *Geol. Mag.* 119: 1-38.
- POULSEN, C., 1934. The Silurian faunas of north Greenland, I, the fauna of the Cape Schuchert Formation. *Medd. om Gronland* 72: 1-46.
- RAYMOND, P. E., 1913. A review of the species which have been referred to the genus *Bathyurus*. *Bull. Victoria mem. Mus.* 1: 51-80.
- RAYMOND, P. E., 1924. New Upper Cambrian and Lower Ordovician trilobites from Vermont. *Proc. Boston Soc. Nat. Hist.* 37: 389-466.
- RAYMOND, P. E., 1937. Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont. *Bull. geol. Soc. Amer.* 48: 1079-1146.
- ROSS, R. J., 1951. Stratigraphy of the Garden City Formation northeastern Utah, and its trilobite faunas. *Bull. Peabody Mus. nat. Hist.* 6: 1-161.

- ROZOVA, A. V., 1968. Biostratigraphy and trilobites of the Upper Cambrian and Lower Ordovician of the north-west Siberian Platform. *Trudy Inst. Geol. i Geofiz.* 36: 1-196.
- SALTER, J. W., 1866. *A monograph of the British trilobites*. Palaeontographical Society Monograph, London, pp. 129-176.
- SDZUY, K., 1955. Die Fauna der Leimitz-Schiefer (Tremadoc). *Abh. senckenb. naturf. Gesell.* 492: 1-74.
- SHENG, S. F., 1934. Lower Ordovician trilobite fauna of Chekiang. *Palaeont. Sinica*, ser. B, 3(1).
- SHERGOLD, J. H., 1975. Late Cambrian and Early Ordovician trilobites from the Burke River Structural Belt, western Queensland, Australia. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 153: 1-251.
- STAIT, B. & LAURIE, J. R., 1980. Lithostratigraphy and biostratigraphy of the Florentine Valley Formation in the Tim Shea area, south-west Tasmania. *Pap. Proc. R. Soc. Tasm.* 114: 201-207.
- SUN, Y. C., 1931. Ordovician trilobites of central and southern China. *Palaeont. Sinica*, ser. B, 7(1).
- THORAL, M., 1935. *Contribution a l'Etude paleontologique de l'Ordovicien inferieur de la Montagne Noire et revision sommaire de la faune cambrienne de la Montagne Noire*. Montpellier, 1-362.
- TJERNVIK, T. E., 1956. On the Early Ordovician of Sweden: stratigraphy and fauna. *Geol. Inst. Univ. Uppsala* 36: 107-284.
- VOGDEN, A. W., 1925. Palaeozoic crustacea, part 2—a list of genera and subgenera of the Trilobita. *Trans. San Diego Soc. Nat. Hist.* 4: 87-115.
- WALCOTT, C. D., 1914. *Dikelocephalus* and other genera of the Dikelocephalinae. *Smithson. misc. Collns* 57: 345-412.
- WALCOTT, C. D., 1925. Cambrian and Ozarkian trilobites. *Smithson. misc. Collns* 75: 61-146.
- WEBBY, B. D., VANDENBERG, A. H. M., COOPER, R. A., BANKS, M. R., BURRETT, C. F., HENDERSON, R. A., CLARKSON, P. D., HUGHES, C., LAURIE, J. E., STAIT, B., THOMSON, M. R. A. & WEBERS, G., 1981. Ordovician System in Australia, New Zealand and Antarctica. *IUGS Publ.* 6: 1-64.
- WHITTINGTON, H. B., 1950. *A monograph of the British trilobites of the Family Harpidae*. Palaeontographical Society Monograph, London, 1-55.
- WHITTINGTON, H. B., 1961. Middle Ordovician Pliomeridae (Trilobita) from Nevada, New York, Quebec, Newfoundland. *J. Paleont.* 35: 911-922.
- XIA, 1978. *Asaphopsis ovoideus* sp. nov. In *Sinian to Permian stratigraphy and palaeontology of the eastern Shanxi area*. Hubei Geological Bureau, ed., Geology Press, Peking, p. 168, pl. 32, figs 13, 14.
- YIN, GONG-SHENG & LI SHEN-CHI, 1978. Class Trilobita. In *Atlas of the palaeontology of the southwestern regions of China*. Guizhou Stratigraphy and Palaeontology Work Team, ed., v. 1, Cambrian-Devonian, 385-594.
- ZHOU, TAN-MEI, LIU, I-JEN, MONG SUNG, & SUN, TZENG-WA, 1977. Trilobita. In *Atlas of the palaeontology of south central China. 1. Early Palaeozoic volume*. Hubei Institute of Geological Sciences, Hubei Geological Bureau, Kwantung Geological Bureau, Honan Geological Bureau, Hunan Geological Bureau, Kwangsi Geological Bureau, eds, Geology Press, Peking, 104-266.
- ZHOU, ZHI-YI & ZHANG, JIN-LIN, 1978. Cambrian-Ordovician boundary of the Tangshan area with descriptions of the related trilobite fauna. *Acta Palaeont. Sin.* 17: 1-28.

Explanation of Plates

PLATE 1

Hystericurus timsheensis sp. nov. All from NMVPL1600.

- Figure 1. Latex cast of damaged cranium distorted by compression in the longitudinal direction; showing wide palpebral lobe and deep fossulae, UTGD122500, $\times 2$.
- Figure 2. Internal mould of two damaged cranidia lying one on top of the other with axes at right angles so that distortion is clearly shown by difference between the two, UTGD122501 and 122502, $\times 2$.
- Figure 3. Latex cast of damaged cranium showing posterior expansion of palpebral lobe, the coarse ornament and a few terrace lines near the anterior margin, UTGD122503, $\times 4$.
- Figure 4. Latex cast from only slightly disarticulated, damaged holotype specimen including cranium, part of thorax, and pygidium, UTGD95867, $\times 2$.
- Figure 5. Latex cast of part of cranium (UTGD122504) and free cheek (UTGD122505) showing ornament completely subdued by distortion in shale after burial, and lateral compression of cheek border near anterior, $\times 3$.
- Figure 6. Latex cast from complete free cheek except for incomplete genal spine showing visual surface, caecal network, terrace lines on border and distinct eye socle, UTGD122506, $\times 6$.
- Figure 7. Latex cast from damaged external mould of pygidium in posterolateral view showing strongly divided axial terminus and high marginal band with well developed terrace lines, UTGD122507, $\times 3.5$.
- Figure 8. Latex cast of damaged pygidium (UTGD122508) and cranium (UTGD122509), $\times 3$.
- Figure 9. Latex cast of damaged pygidium in posterolateral view showing narrow double, marginal terrace lines, and strong medial tubercle on anterior axial ring, UTGD122510, $\times 5$.
- Figure 10. Latex cast of pygidium with ornament and furrows subdued by tectonic distortion, UTGD122511, $\times 4$.
- Figure 11. Latex cast of pygidium showing axial tubercles, extent of pleural furrows, posteromedial marginal indentation, and extent of axis, UTGD122512, $\times 4$.
- Figure 12. Latex cast of damaged fixigena (UTGD122513) and cranium (UTGD122514), showing the tuberculate ornament, upturned palpebral lobe, and anterior structure, $\times 2.5$.
- Figure 13. Internal mould of distorted pygidium showing furrows on pleural areas and divided axial terminus, UTGD122515, $\times 5$.

Figure 14. Latex cast of damaged pygidium showing marginal band in posterior oblique view, UTGD96680, $\times 3.5$.

Figure 15. Internal mould of pygidium (UTGD122516) and librigena (UTGD122517) with external mould of another librigena in upper right (UTGD122518) $\times 2$.

PLATE 2

Hystricurus lewisi (Kobayashi, 1940).

Figure 1. Latex cast of damaged cranidium from NMVPL182 showing flattened anterior border (exaggerating length of border) and wide palpebral lobes, UTGD96055, $\times 5$.

Figure 2. Latex cast of damaged flattened holotype cranidium from limonite encrusted external mould (obliterating surface ornament), Z151, $\times 6$.

Figure 3. Latex cast of an incomplete cranidium from the type locality, Kobayashi's original material, Z995 (= B1423), $\times 4$.

Figure 4. Internal mould of damaged and distorted cranidium from the type locality of *H. lewisi* (holotype of *Tasmanaspis longus* Kobayashi, 1940), Z150, $\times 4$.

Figure 5. Latex cast of small cranidium from NMVPL1601, showing long prelabellar field and wide palpebral lobes, UTGD122519, $\times 4$; A, anterior oblique view; B, dorsal view.

Figure 6. Latex cast of small cranidium from NMVPL182, UTGD122520, $\times 3$.

Figure 7. Latex cast of small cranidium from NMVPL182 crushed down on right antero-lateral corner so that palpebral lobe appears narrow because most of its width is turned directly down and prelabellar field appears short because it is depressed and compressed with border strongly upturned, UTGD122521, $\times 3.5$.

Figure 8. Latex cast of cranidium from 5 Road, showing ornament, anterior course of facial suture, and palpebral lobes, UTGD81067, $\times 3$.

Figure 9. Internal mould of librigena from NMVPL182 showing coarse ornament and anterior extent of doublure, UTGD122522, $\times 3.5$.

Figure 10. Internal mould (A) and latex cast (B) of small librigena from NMVPL183, in dorsal view, showing difference of ornament on inner and outer surfaces of exoskeletons, terrace lines on the border and anterior extension of border, UTGD122523, $\times 5$.

Figure 11. Internal mould of a cranidium from NMVPL1602, UTGD81062, $\times 3.5$.

Figure 12. Latex cast of damaged librigena from NMVPL1602, in lateral oblique view showing visual surface and eye socle, UTGD96710, $\times 5$.

Figure 13. Latex cast of damaged cranidium from 5 Road showing wide palpebral lobes and posterior cephalic limb, UTGD81049, $\times 5$.

Figure 14. Latex cast of librigena with most of genal spine missing from NMVPL182, in lateral oblique view, showing border furrow shallowing at rear and high eye socle, UTGD98084, $\times 4$.

Figure 15. Latex cast of two cranidia and a pygidium with a cranidium of *Asaphopoides florentinensis* lying between the cranidia of this species, from NMVPL182, showing the different morphologies produced by the different orientation relative to the slaty cleavage—compression has been in the direction up and down the page so that the upper cranidium is compressed laterally whereas lower one is compressed in sagittal line, also showing weak 1p furrow, UTGD122524, 122525, 122526 and 122527 from top to bottom respectively, $\times 3$.

PLATE 3

Figures 1-7. *Tanybregma tasmaniensis* sp. nov. All from NMVPL1600.

Figure 1. Latex cast of damaged librigena showing visual surface, anterior extent of doublure and denticles on adaxial margin of genal spine, UTGD122528, $\times 4$.

Figure 2. Internal mould of distorted cranidium, UTGD96674, $\times 4$.

Figure 3. Internal mould of holotype cranidium showing long prelabellar length, palpebral lobes, 1p furrow, and course of facial suture, UTGD 95983, $\times 3.5$.

Figure 4. Latex cast of librigena in ventral view showing terrace lines on the doublure, ridge running down genal spine, and denticles on genal spine, UTGD96676, $\times 2$.

Figure 5. Latex cast of incomplete librigena showing extent of doublure forward of facial suture and width of doublure, UTGD122529, $\times 3$.

Figure 6. Internal mould of librigena showing visual surface, course of facial suture, and mould of ridge on underside of genal spine, UTGD 122530, $\times 4$.

Figure 7. Internal mould of damaged cranidium showing caecal network on prelabellar area, concave border, and posterior limb, UTGD122531, $\times 2$.

Figures 8, 11, 12, 14. *Hystricurus* sp. cf. *H. robustus* Ross, 1951

Figure 8. Latex cast of pygidium from NMVPL1602 showing axial structure, extent of furrows on pleurae, and occasional coarse tubercles on axial rings and pleural ribs, UTGD95885, $\times 6$.

Figure 11. Internal mould of pygidium from NMVPL 1602 showing fine tubercles representing pits on the inner surface of exoskeleton, and the width of the doublure, UTGD122532, $\times 3$.

Figure 12. Latex cast of part of thorax and posterior of cranium from Adams Falls, UTGD96040, $\times 4$.

Figure 14. Internal mould of pygidium from Adams Falls, UTGD96620, $\times 3$.

Figures 9, 10, 13. *Hystricurus lewisi* Kobayashi, 1940 all from NMVPL182.

Figure 9. Latex cast of incomplete pygidium showing rim-like anteriorly tapering border, the strong ridge at the geniculation, and steeply sloping outer part of pleura, UTGD122533, $\times 4$.

Figure 10. Internal mould of pygidium showing doublure and structure of axis, UTGD96049, $\times 7$.

Figure 13. Latex cast of slightly distorted pygidium showing pleural and interpleural furrows, and sharp geniculation, UTGD98080, $\times 7$.

PLATE 4

Figures 1-7. *Hystricurus* sp. cf. *H. robustus* Ross, 1951.

Figure 1. Internal mould of damaged cranium from NMVPL1602 showing coarse ornament and long posterior limb, UTGD122534, $\times 4$.

Figure 2. Internal mould of librigena from Adams Falls showing the visual surface, doublure, and deflected genal spine, UTGD95913, $\times 3$.

Figure 3. Internal mould of damaged cranium from Adams Falls showing extremely short preglabellar field, UTGD96626, $\times 2.5$.

Figure 4. Internal mould of cranium from Adams Falls showing palpebral lobe and posterior course of facial suture, UTGD96603, $\times 3.5$.

Figure 5. Latex cast of librigena from NMVPL1602 showing terrace lines on the border, eye socle and collapsed visual surface, UTGD98114, $\times 4$.

Figure 6. Latex cast of damaged cranium from Adams Falls showing palpebral lobes, extremely short preglabellar field with median furrow, and posteriorly shallowing axial furrow, UTGD 96708, $\times 3$.

Figure 7. Latex cast of small librigena from Adams Falls showing visual surface, eye socle, shallowing in border furrow just in front of genal angle, and coarse ornament, UTGD122588, $\times 7$.

Figures 8-11. *Chosenia adamsensis* sp. nov. All from Adams Falls.

Figure 8. Latex cast of damaged pygidium showing terrace lines on marginal spines and axial structure, UTGD95175, $\times 4$.

Figure 9. Latex cast of cranium showing long glabellar furrows and marginal terrace lines on anterior border, UTGD96027, $\times 3$.

Figure 10. Latex cast of incomplete pygidium showing curved marginal spine with terrace lines, ridges on pleural ribs in position of interpleural furrows, and marginal spine coming from third pygidial segment, UTGD96611, $\times 2$.

Figure 11. Internal mould of pygidium distorted by shortening, showing apodemal pits in transaxial furrows, anterior border furrow reaching margin in front of marginal spine, and doublure, UTGD96602, $\times 3$.

Figure 12. *Asaphellus etheridgei* sp. nov. Internal mould of pygidium from Adams Falls showing terrace lines on doublure, apodemal pits in transaxial furrows, and axial shape, UTGD96032, $\times 1.5$.

Figure 13. Nileidae gen. et sp. indet. Internal mould of pygidium and five thoracic segments from Adams falls, UTGD96030, $\times 2.5$. (NOT DESCRIBED).

PLATE 5

Chosenia adamsensis sp. nov. All from Adams Falls except Fig. 1 which is from NMVPL1602.

Figure 1. Latex cast of damaged holotype cranium showing long glabellar furrows and ridge crossing axial furrow from anterolateral corner of glabella, UTGD122535, $\times 2$.

Figure 2. Latex cast of damaged librigena showing terrace lines, and course of border furrow, UTGD95945, $\times 4$.

Figure 3. Internal mould (A) and latex cast from external mould (B) showing sparse tuberculate ornament, strong caecum from anterolateral corner of glabella, ten thoracic segments with wide pleural spines, and characteristic long anterior border furrow on pygidium, UTGD96023, $\times 3$.

Figure 4. Latex cast of damaged cranium showing anterior marginal terrace lines, posterior palpebral lobe, and tuberculate ornament on glabellar lobes, UTGD96029, $\times 4.5$.

Figure 5. Latex cast of librigena showing structure of border, eye socle, terrace lines and genal spine, UTGD96646, $\times 5$.

Figure 6. Internal mould of damaged cranium, UTGD95927, $\times 3$.

Figure 7. Internal mould of damaged laterally compressed pygidium showing long marginal, spine arising from second pygidial segment, anterior border furrow running to margin forward of marginal spine, and axis of six segments plus terminus, UTGD95942, $\times 2$.

Figure 8. Latex cast of damaged, sagittally compressed pygidium showing marginal spines with longitudinal terrace lines and issuing from third pygidial segment, seven axial rings plus terminus, and interpleural furrows, UTGD 96644, $\times 3$.

Figure 9. Internal mould of diagonally distorted pygidium, UTGD96025, $\times 2$.

Figure 10. Internal mould of sagittally compressed pygidium showing terrace lines on doublure, axis of seven rings and terminus, and marginal spine issuing from third segment, UTGD96637, $\times 2$.

PLATE 6

Asaphellus sp. cf. *A. trinodosus* Chang, 1949. All from NMVPL1602

Figure 1. Latex cast from incomplete external mould of cranium showing palpebral lobe and course of facial suture, UTGD98111, $\times 2$.

Figure 2. Latex cast from incomplete external mould of hypostome showing concentric terrace lines, median furrows, shape of the median body, and slight medial expansion of the posterior border, UTGD98137, $\times 4.5$.

Figure 3. Latex cast from external mould of holotype cranium showing weakly defined glabella, palpebral lobes, facial suture barely diverging in front of palpebral lobes, and faint node posteromedially on glabella, UTGD96005, $\times 2$.

Figure 4. Latex cast of ventral surface of librigena showing terrace lines on wide convex doublure, UTGD95917, $\times 1$.

Figure 5. Latex cast of incomplete librigena showing eye socle, short genal spine, and fine terrace lines near margin, UTGD95895, $\times 2$.

Figure 6. Latex cast of damaged cranium showing weak axial furrow, and palpebral lobes, UTGD96002, $\times 3$ (thoracic segment of some other trilobite impressed through the cranium just forward of palpebral lobes).

Figure 7. Latex cast of damaged librigena showing anterior termination of doublure in sagittal suture, eye socle, and marginal terrace lines, UTGD98117, $\times 2$.

Figure 8. Internal mould of pygidium showing wide doublure, low convexity and terrace lines on the doublure (on right), UTGD122536, $\times 1.5$.

Figure 9. Internal mould of damaged cranium showing axial furrow, palpebral lobes, and posterior course of facial suture, UTGD122537, $\times 1.5$.

Figure 10. Latex cast of right posterolateral part of hypostome showing deep median furrow, terrace lines on the border with narrow upturned margin and short posterior margin, UTGD122538, $\times 2$.

Figure 11. Internal mould of pygidium showing axial structure including transverse apodemes, pleural and interpleural furrows and wide doublure with terrace lines, UTGD95877, $\times 2$.

Figure 12. Latex cast of pygidium and librigena, UTGD95915 and 122539, respectively, $\times 1.5$.

PLATE 7

Megistaspis (Ekeraspis) euclides (Walcott, 1925). All from NMVPL1601.

Figure 1. Internal mould of damaged cranium, UTGD122540, $\times 1.5$.

Figure 2. Latex cast of incomplete cranium showing course of the facial suture, palpebral lobe, and low convexity of the cranium, UTGD122541, $\times 2$.

Figure 3. Latex cast of ventral side of librigena showing long genal spine with ridge running down it, wide doublure with terrace lines, and sagittal suture terminating doublure anteriorly, UTGD122542, $\times 1$.

Figure 4. Internal mould of cranium, UTGD122543, $\times 1$.

Figure 5. Internal mould of incomplete librigena showing eye socle, facial suture and wide anterior doublure, UTGD98095, $\times 2$.

Figure 6. Latex cast from incomplete external mould of hypostome showing dorsally projecting anterior wings, terrace lines, and deep median furrow, UTGD122544, $\times 2$.

Figure 7. Latex cast of damaged librigena showing eye socle, flat border, and course of facial suture, UTGD122545, $\times 1.5$.

Figure 8. Latex cast from incomplete external mould of cranium showing extent of glabella, anterior part of facial suture and its most posterior part, UTGD122546, $\times 2$.

Figure 9. Internal mould of small pygidium showing long posterior spine, UTGD122547, $\times 2$.

Figure 10. Latex cast of posterior part of hypostome showing terrace lines on the shoulder and short posterior lobe of median body, UTGD122548, $\times 4$.

Figure 11. Latex cast of large pygidium showing axial and pleural structure, UTGD95994, $\times 1$.

Figure 12. Latex cast of damaged hypostome, UTGD122549, $\times 3$.

Figure 13. Latex cast of sagittally compressed pygidium showing shorter posterior spine, UTGD98102, $\times 3$.

Figure 14. Latex cast of small distorted pygidium, UTGD122550, $\times 3$.

Figure 15. Internal mould of laterally compressed pygidium plus posterior five thoracic segments showing pygidial doublure with terrace lines, and style of thoracic segment, UTGD122551, $\times 2$.

PLATE 8

Dikelokephalina asiatica Kobayashi, 1934. All from NMVPL1600.

Figure 1. Latex cast of small fragment of a librigena probably referable to this species showing low eye socket and ornament of subtle terrace lines on genal field, UTGD122552, $\times 2$.

Figure 2. Internal mould of damaged laterally compressed pygidium showing axial structure and posterior spines, UTGD95981, $\times 3$.

Figure 3. Internal mould of pygidium, UTGD95979, $\times 3$.

Figure 4. Latex casts from internal or ventral (A) and external (B) moulds of damaged pygidium showing subtle terrace lines on border region, width of doublure and its terrace lines, posterior notch in inner edge of doublure and posterior spines, UTGD96689, $\times 2.5$.

Figure 5. Internal mould of damaged pygidium, UTGD95982, $\times 3$.

Figure 6. Latex cast of damaged cranidium showing palpebral lobe, glabellar furrows and fine tuberculate ornament, UTGD95980, $\times 3$.

Figure 7. Internal mould of cranidium showing palpebral lobes, glabellar furrows, occipital node and preglabellar structure, UTGD122553, $\times 3$. (Cranidium of *Tanybregma tasmaniensis* sp. nov. in upper left UTGD122554).

Figure 8. Internal mould of damaged cranidium, UTGD95978, $\times 3$.

PLATE 9

Asaphopsoides florentinensis (Etheridge, 1905). All from NMVPL182 except Figures 5, 6, 8, 11 which come from 5 Road.

Figure 1. Internal mould of juvenile cranidium, UTGD122555, $\times 7$.

Figure 2. Internal mould of juvenile cranidium larger than previous one, UTGD98053, $\times 5$.

Figure 3. Internal mould of damaged hypostome, UTGD122556, $\times 4$.

Figure 4. Latex cast from incomplete external mould of cranidium showing fine terrace lines on anterior border, UTGD81086, $\times 2.5$.

Figure 5. Latex cast of hypostome showing ornament, median furrow, pits in posterior border furrow, and short posterior border, UTGD81019, $\times 6$.

Figure 6. Latex cast of incomplete cranidium and librigena, UTGD80990 and 122557 respectively, $\times 3$.

Figure 7. Internal mould of cranidium showing posterolateral limbs, and fossulae, UTGD122558, $\times 2.5$.

Figure 8. Latex cast of right pleura of thoracic segment showing ornament, facet, and pointed tip, UTGD122559, $\times 3$.

Figure 9. Latex cast of damaged sagittally compressed cranidium showing glabellar furrows, terrace lines on anterior border, palpebral lobes, and occipital node, UTGD98075, $\times 5$.

Figure 10. Latex cast of damaged cranidium diagonally distorted, UTGD122560, $\times 3$.

Figure 11. Internal mould of damaged cranidium, UTGD80999, $\times 3$.

PLATE 10

Asaphopsoides florentinensis (Etheridge, 1905).

Figure 1. Internal mould of laterally compressed holotype pygidium from near 'The Gap' in the Florentine Valley AMF9232, $\times 2$.

Figure 2. Internal mould of incomplete librigena from Adams Falls showing broad genal spine and wide doublure, UTGD96022, $\times 4$.

Figure 3. Latex cast of joined librigenae and anterior border of cranidium from 5 Road showing facial suture, genal spines and border furrow, UTGD81001, $\times 1.5$.

Figure 4. Internal mould of laterally compressed pygidium from Adams Falls showing wide doublure with terrace lines and pleural and interpleural furrows, UTGD96036, $\times 3$.

Figure 5. Latex cast (A) and internal mould (B) of pygidium and nine thoracic segments from NMVPL182 showing increasing curvature of pleural spines posteriorly, UTGD96652, $\times 3$.

Figure 6. Latex cast of ventral side of librigena from 5 Road showing sagittal suture terminating doublure anteriorly, wide doublure and course of facial suture, UTGD96650, $\times 2$.

Figure 7. Internal mould of damaged pygidium from NMVPL182 showing axial structure and broadly excavated margin posteromedially between marginal spines, UTGD98060, $\times 4$.

Figure 8. Internal mould of laterally compressed pygidium from Adams Falls showing terrace lines on doublure and posterior marginal spines, UTGD80995, $\times 3$.

Figure 9. Latex cast of pygidium from NMVPL182, showing axial and pleural structure, UTGD122561, $\times 2.5$.

Figure 10. Internal mould of damaged pygidium from Adams Falls showing width of doublure with terrace lines and posterior marginal spines, UTGD96038, $\times 2.5$.

PLATE 11

Figures 1-3. *Protopliomerops* sp. cf. *P. punctatus* Kobayashi, 1934. All from NMVPL1602.

Figure 1. Latex cast from incomplete external mould of cranium, UTGD122562, $\times 6$.

Figure 2. Internal mould of cranium and anterior thoracic segments of enrolled individual showing transverse glabellar furrows, UTGD122563, $\times 8$.

Figure 3. Internal mould of two cranidia showing transverse (lower) and oblique (upper) glabellar furrows, UTGD122564 and 122565, $\times 5$.

Figures 4-14. *Scotoharpes lauriei* sp. nov. All from NMVPL1602.

Figure 4. Internal mould of damaged cranium, UTGD95922, $\times 9$.

Figure 5. Latex cast from incomplete external mould of cranium showing glabellar furrows, occipital node, eyes, and eye ridges, UTGD121496, $\times 11$. (Broken off just outside girder).

Figure 6. Latex cast of ventral surface of incomplete cranium showing extent of girder, projecting rim at margin, inner extent of doublure and caecal network, UTGD98116, $\times 6$.

Figure 7. Latex cast from damaged external mould of cranium with three thoracic segments attached showing spine on tip of prolongation, eyes and caecal network, UTGD122566, $\times 4$.

Figure 8. Internal mould of damaged cranium showing extent of girder, UTGD122567, $\times 10$.

Figure 9. Latex cast from damaged external mould of holotype specimen, UTGD121586, $\times 6$.

Figure 10. Latex cast from damaged external mould of small cranium in anterolateral oblique view showing marginal rim and eye, UTGD122568, $\times 7$.

Figure 11. Latex cast from damaged external mould of small cranium showing spine on tip of prolongation, UTGD96007, $\times 10$.

Figure 12. Latex cast of dorsal (A) and ventral (B) surfaces of damaged cranium showing caecal network and girder, UTGD122569, $\times 5$ and $\times 6$ respectively.

Figure 13. Internal mould of pygidium and posterior thoracic segment showing tapering axis, narrow border and smooth pleural areas, UTGD96010, $\times 9$.

Figure 14. Internal mould of a cranium, UTGD96008, $\times 8$.

PLATE 12

Figures 1-4. *Pilekiidae* gen. et sp. nov. From NMVPL1601.

Figure 1. Latex cast of damaged cranium in anterior (A), anterolateral oblique (B), and dorsal (C) views, UTGD122570, $\times 3$, $\times 3$ and $\times 5$, respectively.

Figure 2. Latex cast of damaged cranium, UTGD122571, $\times 5$.

Figure 3. Latex cast of pygidium showing pleural and interpleural furrows and marginal spines, UTGD122572, $\times 6$.

Figure 4. Latex cast of pygidium in dorsal (A) and left lateral oblique (B) views, UTGD122573, $\times 7$.

Figures 5-7. *Protopliomerops* sp. cf. *P. punctatus* Kobayashi, 1934. From NMVPL1602.

Figure 5. Latex cast of pygidium showing six marginal spines on left side, UTGD122574, $\times 10$.

Figure 6. Latex cast of pygidium showing six marginal spines on right side, UTGD122575, $\times 6$.

Figure 7. Latex cast of pygidium showing six marginal spines on both sides, UTGD122576, $\times 8$.

Figures 8-12. *Pilekia* sp. nov. All from NMVPL1600.

Figure 8. Internal mould of sagittally compressed cranium showing prominent 1p lobes and strong genal spine (detailed in (B) where its external mould is visible), UTGD122577, $\times 2.5$.

Figure 9. Latex cast of incomplete and distorted cranium showing pitted ornament of cheek and nature of palpebral lobe, UTGD96664, $\times 2$.

Figure 10. Latex cast of damaged cranium showing ornament and glabellar furrows, UTGD122578, $\times 3$.

Figure 11. Internal mould of damaged cranium showing genal spine, glabella and ornament, UTGD95987, $\times 2$.

Figure 12. Internal mould of damaged holotype pygidium showing four marginal spines of different sizes, interpleural furrows, and ornament, UTGD95989, $\times 4$.

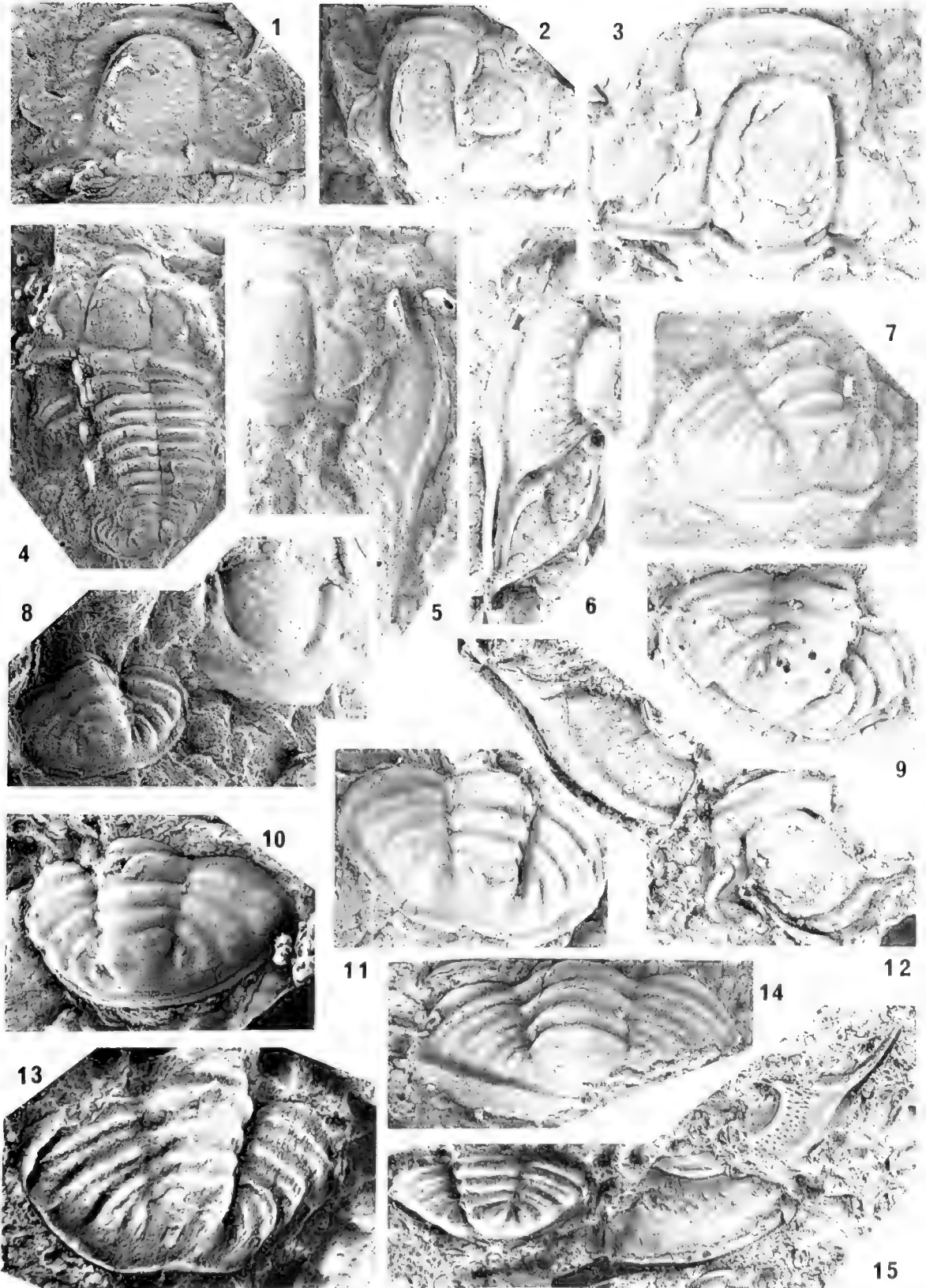
PLATE 13

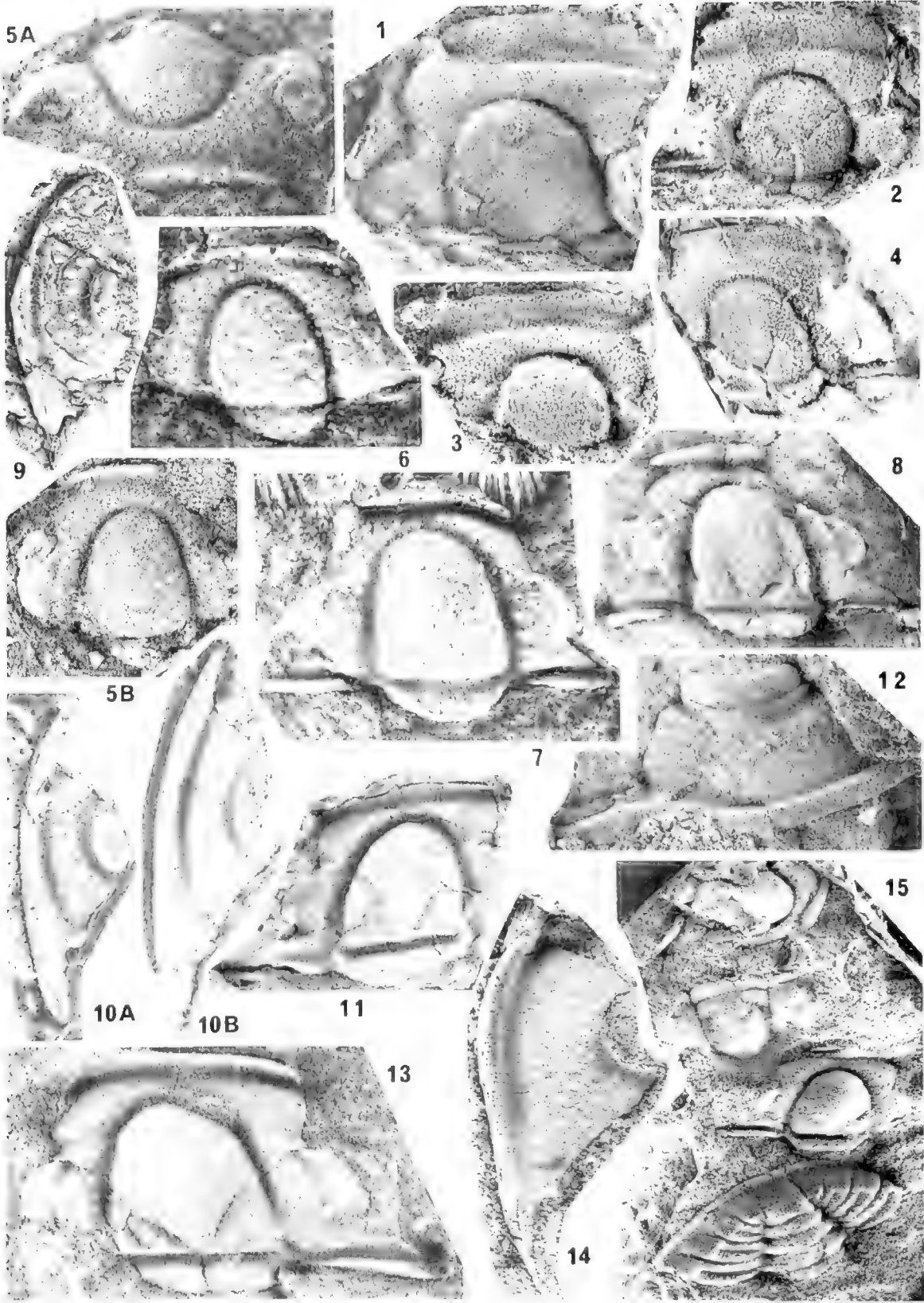
Protopliomerops hamaxitus sp. nov. All from NMVPL1602.

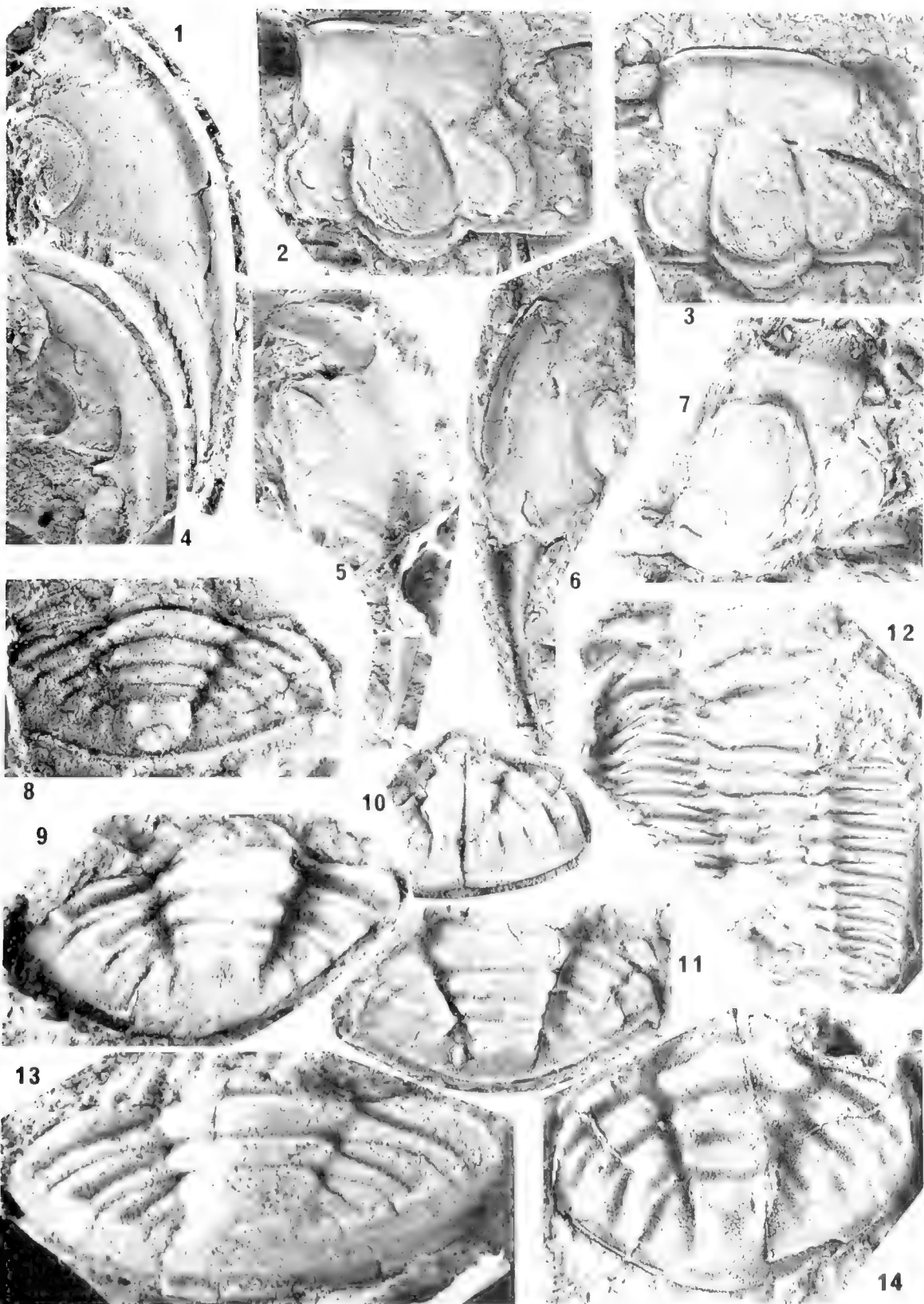
Figure 1. Latex cast of cranium showing genal spines, UTGD95999, $\times 8$.

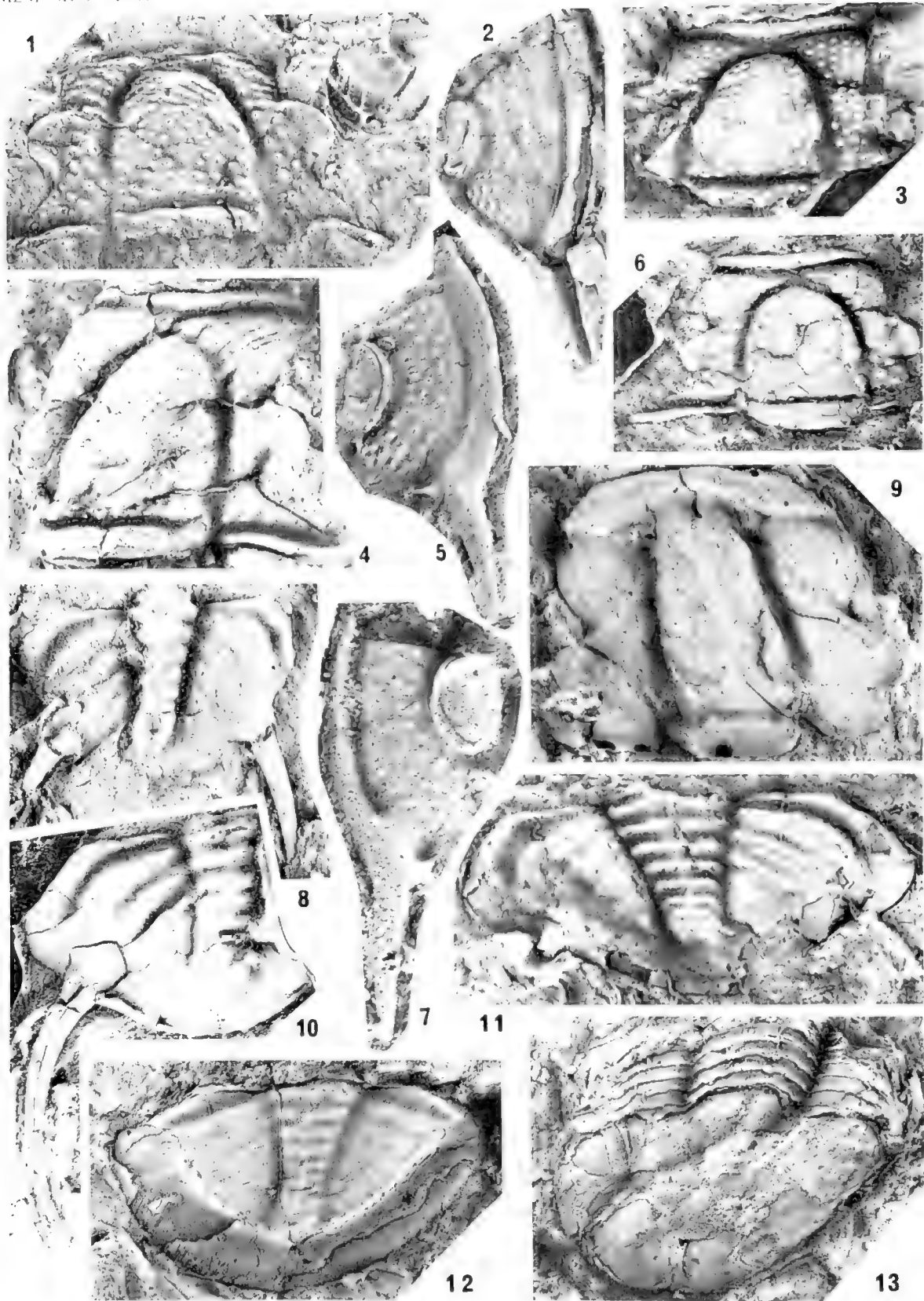
Figure 2. Latex cast of pygidium showing five pairs of well separated marginal spines and pustulose ornament, UTGD95886, $\times 10$.

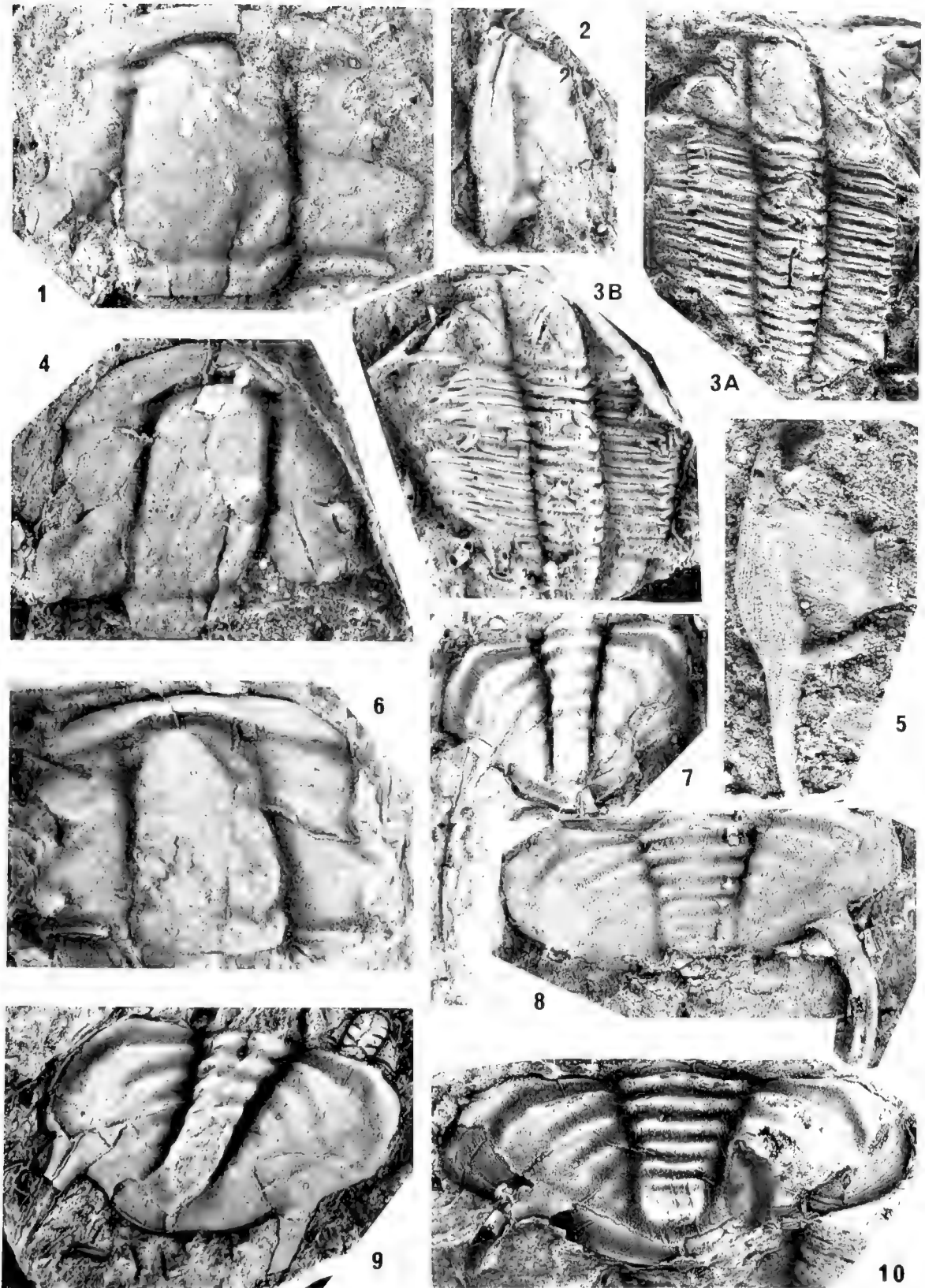
- Figure 3. Latex cast of hypostome showing anterior wings and pustulose ornament, UTGD96003, $\times 20$.
- Figure 4. Latex cast of rear of thorax and pygidium of juvenile individual, UTGD122579, $\times 12$.
- Figure 5. Latex cast of sagittally compressed cranium showing glabellar furrows, palpebral lobe, and punctate ornament on cheek, UTGD121491, $\times 8$.
- Figure 6. Latex cast of damaged cranium with librigena in place, UTGD122580, $\times 11$.
- Figure 7. Latex cast of damaged cranium and thorax, UTGD122581, $\times 8$.
- Figure 8. Latex cast of hypostome showing ornament and faint median furrow, UTGD122582, $\times 8$.
- Figure 9. Latex cast of damaged complete specimen showing 13 segments, UTGD96625, $\times 10$.
- Figure 10. Internal mould of damaged individual showing position of hypostome, free pleural spines and strong thoracic apodemes in articulating furrows, UTGD122583, $\times 9$.
- Figure 11. Latex cast of two crania, UTGD95884 (upper) and 122584 (lower), $\times 6$.
- Figure 12. Latex cast of damaged holotype cranium showing ornament, glabellar furrows, lp joining occipital furrow, and short anterior border, UTGD122585, $\times 9$.
- Figure 13. Latex cast of pygidium with large quadrate axial terminus, UTGD122586, $\times 8$.
- Figure 14. Latex cast of damaged cranium and thorax, UTGD122587, $\times 6$.

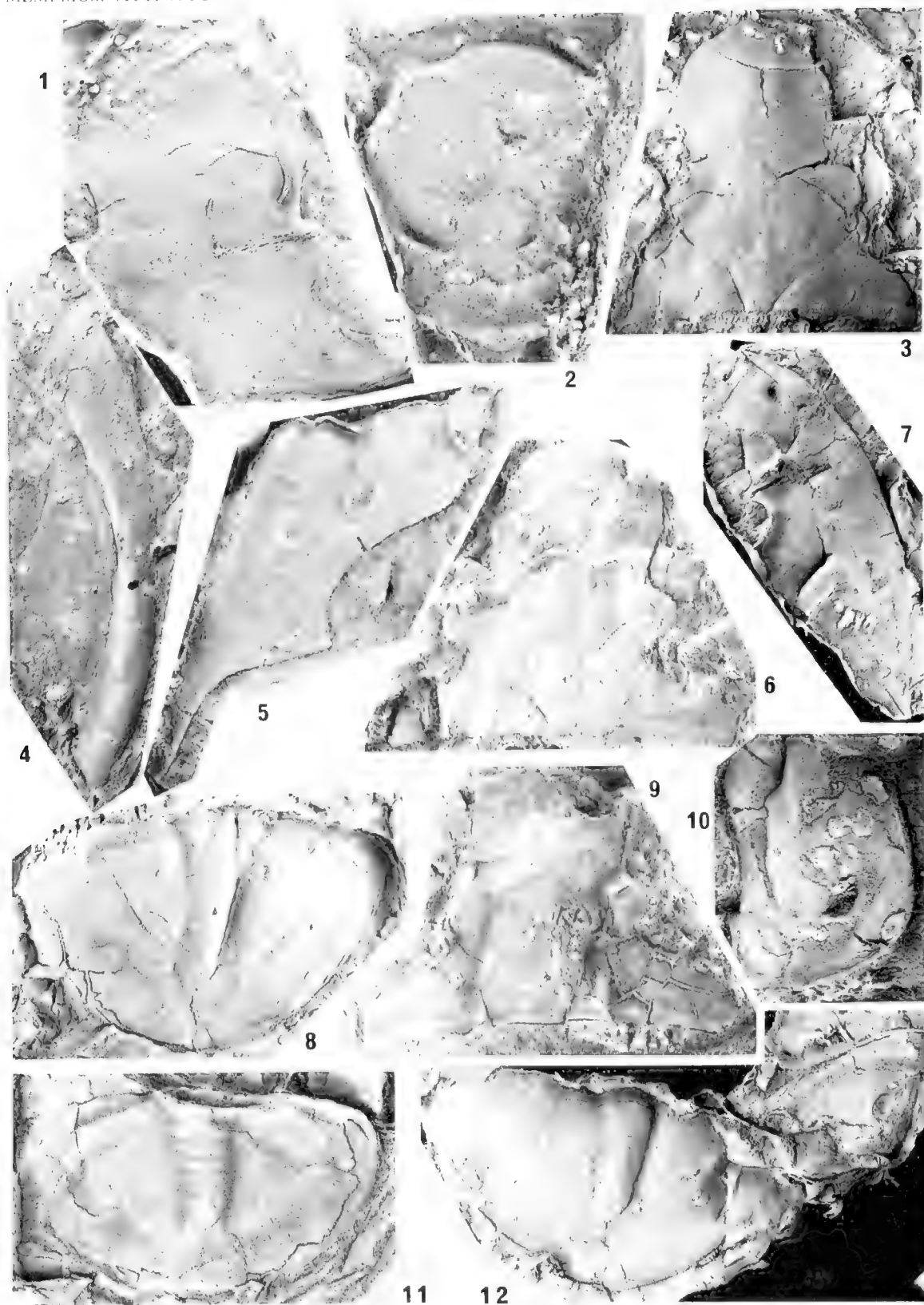


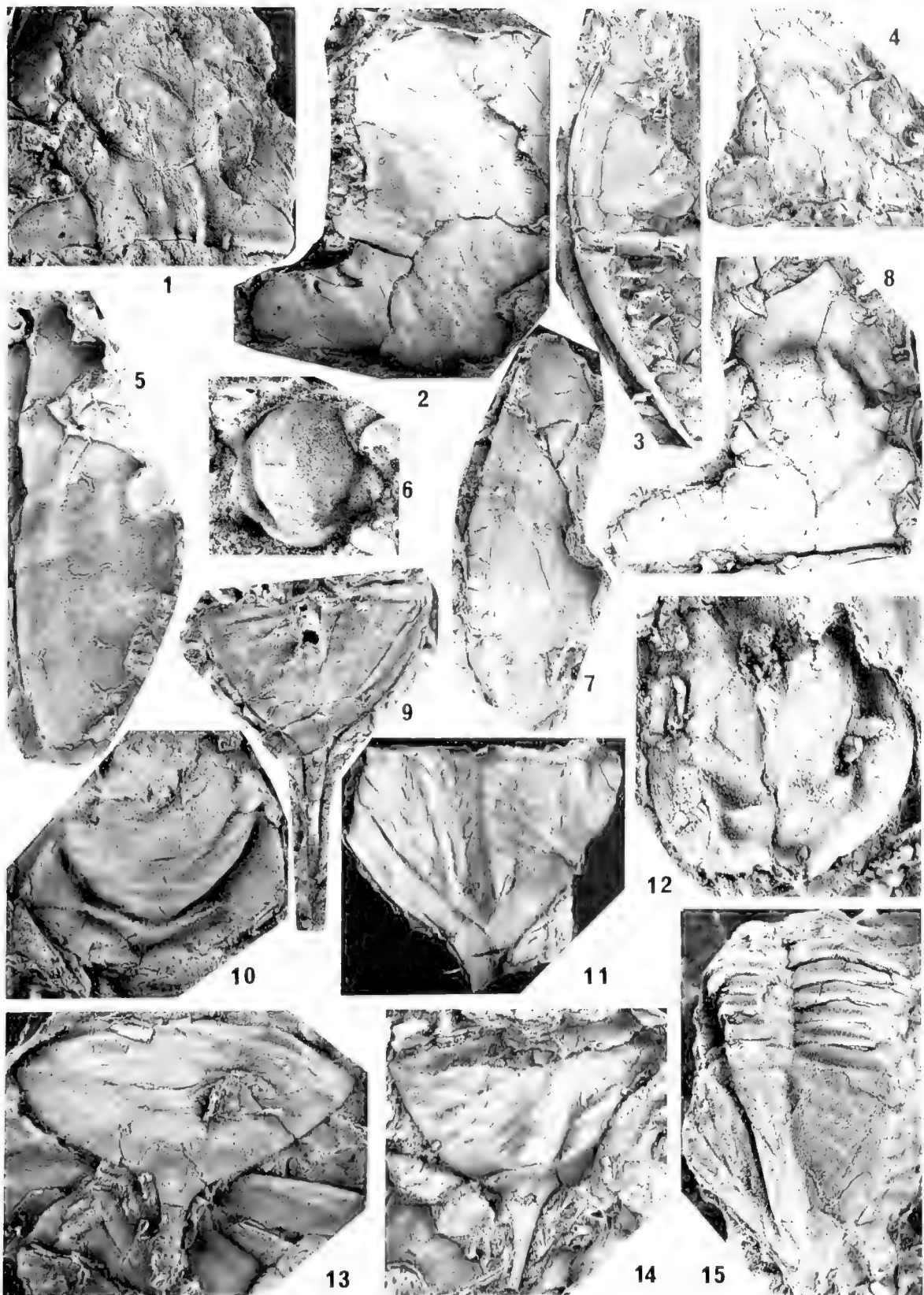


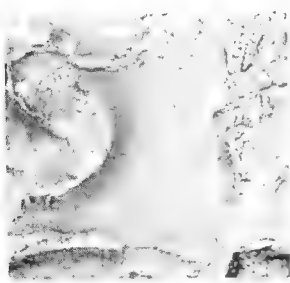




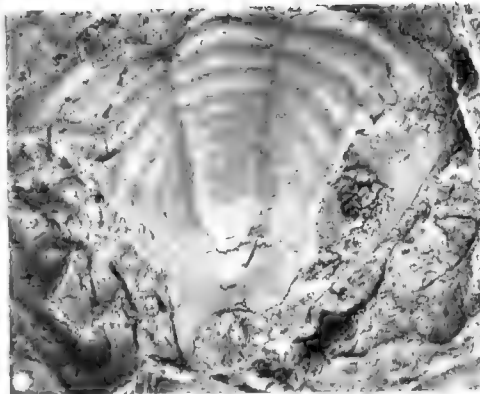








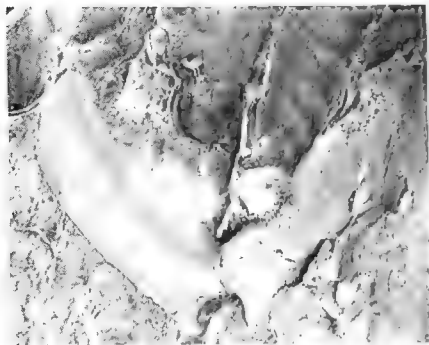
1



2



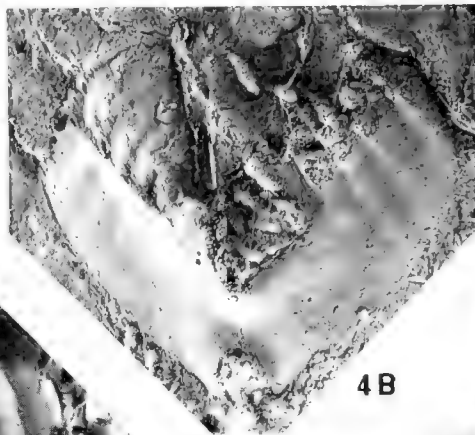
3



4 A



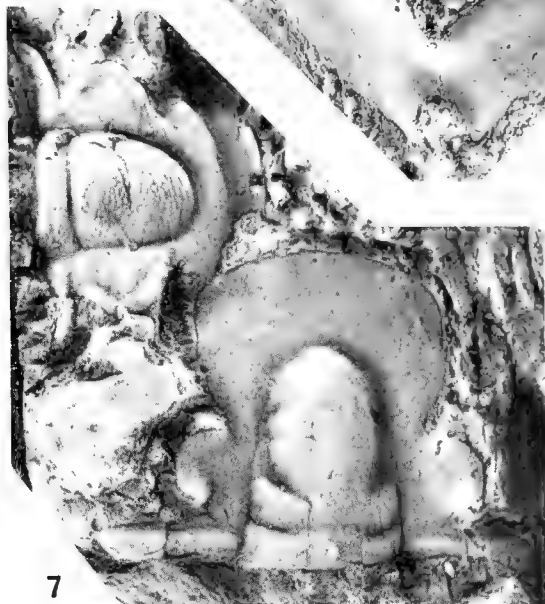
5



4 B



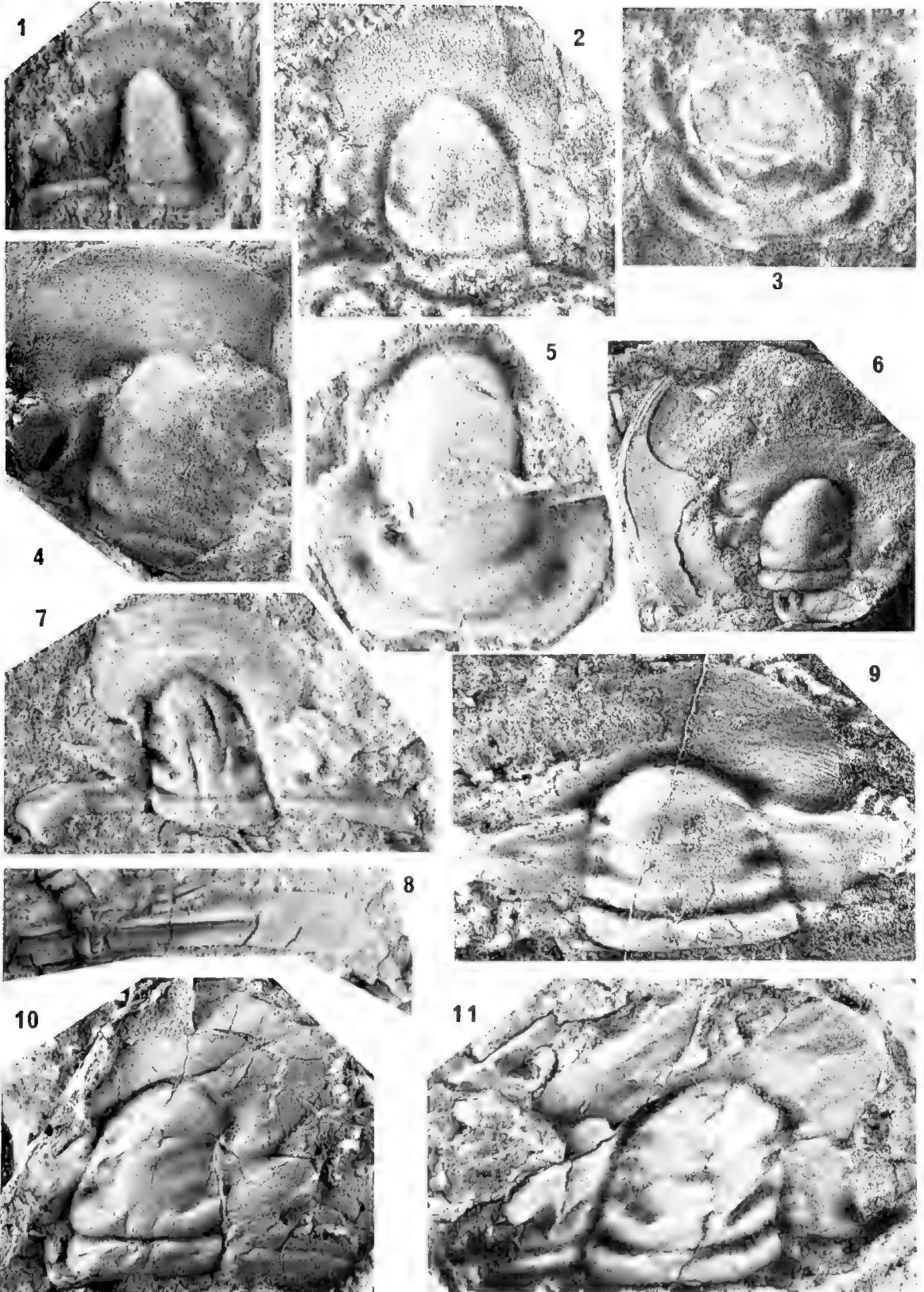
6

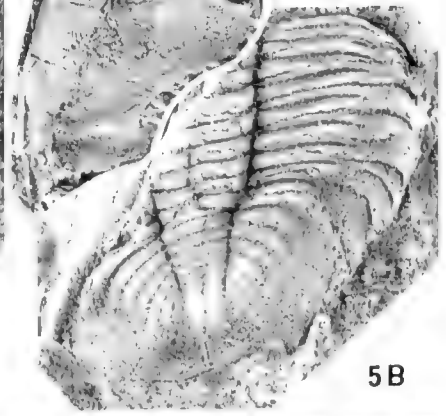
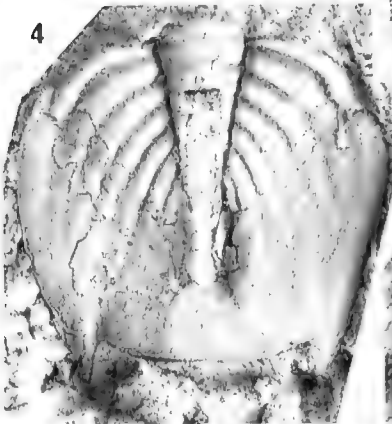
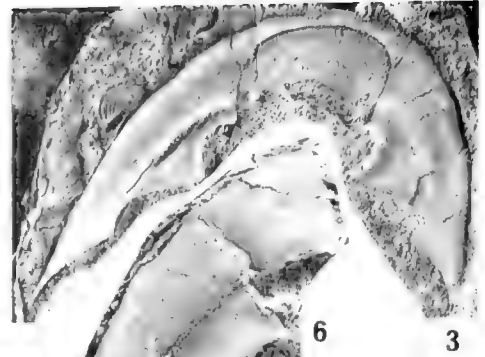
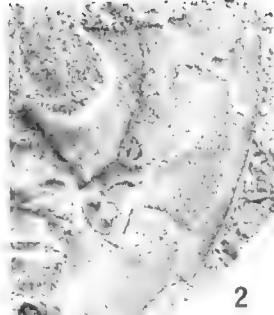
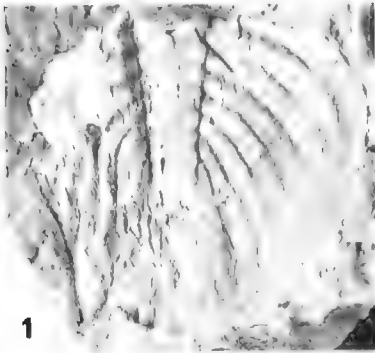


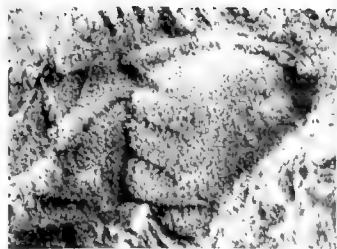
7



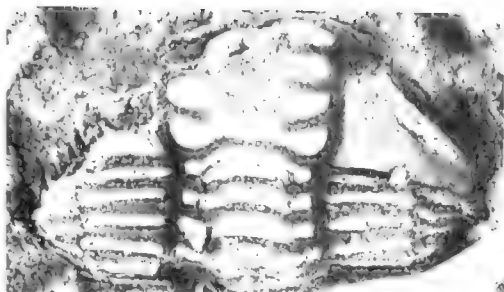
8







1



2



3



4

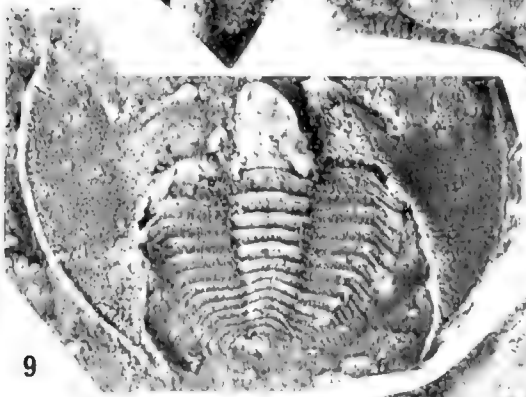


5



6

7



9



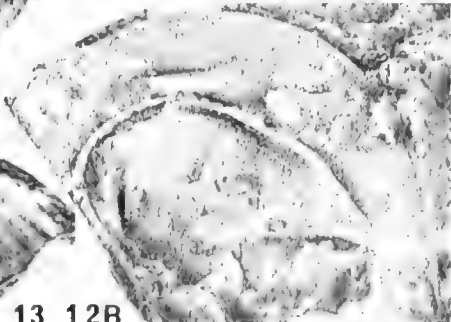
12A



10

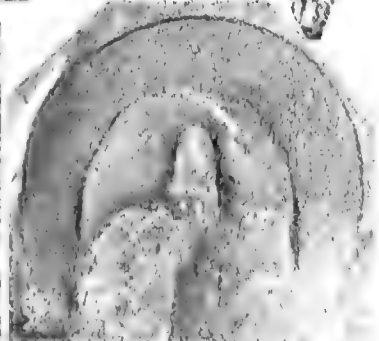


11

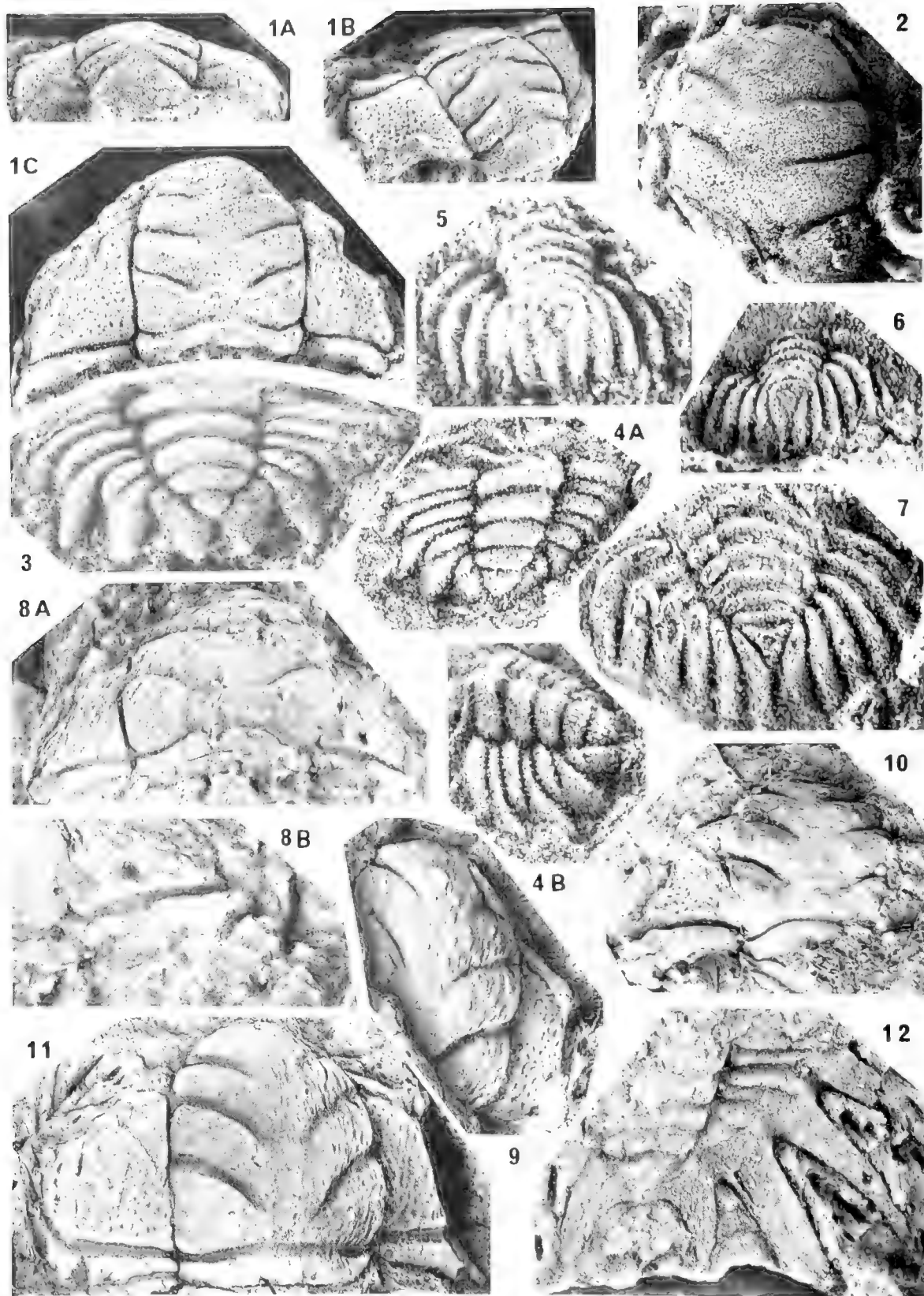


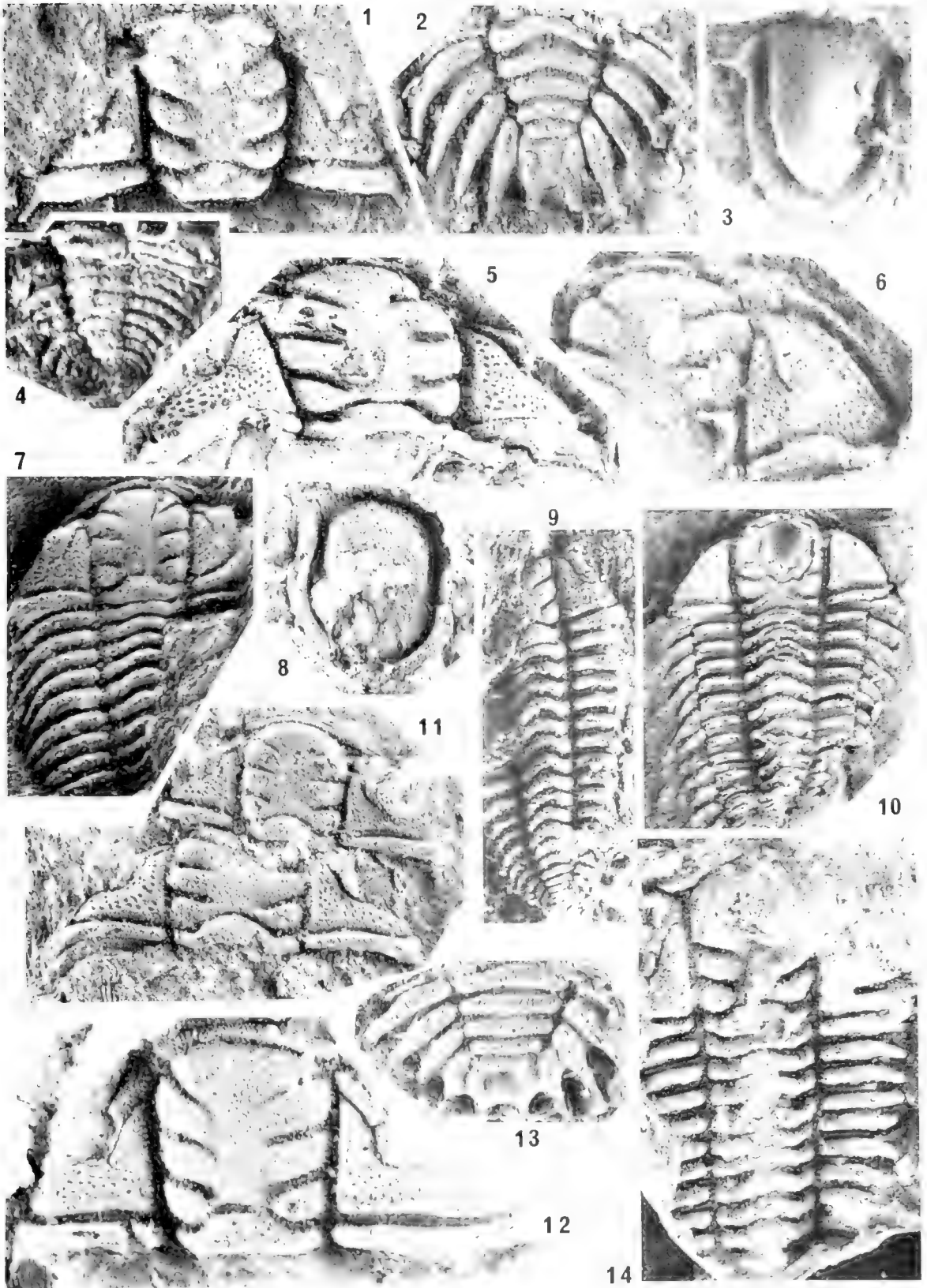
13

12B



14





REVISION OF AN EARLY ARENIG TRILOBITE FAUNULE FROM THE CAROLINE CREEK SANDSTONE, NEAR LATROBE, TASMANIA

BY P. A. JELL* AND B. STAIT†

* Department of Invertebrate Fossils, Museum of Victoria, 285-321 Russell Street, Melbourne, Victoria 3000.

† Department of Geology, University of Tasmania, G.P.O. Box 252C, Hobart, Tasmania 7001.

Abstract

A trilobite faunule from the Caroline Creek Sandstone near Latrobe, Mersey District, Tasmania is revised with five species being recognised, namely, *Etheridgaspis carolinensis* (Etheridge), *Carolinites tasmaniensis* (Etheridge), *Tasmanocephalus stephensi* (Etheridge), *Parabasiliscus ? lewisi* (Kobayashi), *Protoencrinurella ? subquadrata* (Kobayashi). *Carolinites tasmaniensis* is recognised as a senior synonym of the type species of the genus, *C. bulbosus* Kobayashi, and of *C. genacinaca nevadensis* Hintze. *Tasmanocephalus* is referred to the Missisquoiidae and *Etheridgaspis* to the Hystericuridae. The age of this faunule is considered to be early Arenig (*D. deflexus* zone).

Introduction

The fauna of the Caroline Creek Sandstone has not been fully described but a trilobite faunule from a prolific locality near Latrobe in the Mersey River District of northern Tasmania (Fig. 1) was extensively collected during the latter part of the nineteenth century and collections dispersed to numerous museums in many parts of the world. Robert Etheridge Jr (1883) published the first taxonomic study of this material. He erected *Conocephalites stephensi* for a number of cranidia and *Dikelocephalus tasmanicus* for several pygidia, as well as referring to two species of *Asaphus* and four generically-unassigned species of ptychoparioids in open nomenclature. He concluded that the age was equivalent to that of the Lingula Flags in Britain and the Potsdam Sandstone of North America (i.e. Late Cambrian).

In 1919 Etheridge revised the taxonomy of the faunule without illustration. He assigned *Dikelocephalus tasmanicus* to *Crepicephalus* and recognised that *Conocephalites stephensi* was the cranidium of the same species. He erected three species for the four non-asaphids he had left in open nomenclature in 1883 and referred them questionably to *Ptychoparia*.

The further study of this faunule was undertaken by Kobayashi (1936, 1940). In 1936 he reported on the collection in the British Museum (Natural History) recognising the generic distinctions of Etheridge's species *stephensi* with the name *Tasmanocephalus* and

assigning an Early Ordovician age to the faunule. In 1940 he carried out a full revision based on a new collection sent to him by Dr A. N. Lewis but unfortunately did not refer to the original material of Etheridge. He erected two genera (*Carolinites* and *Etheridgaspis*) and four species (*C. bulbosa*, *C. quadrata*, *Prosopiscus ? subquadrata* and *Asaphellus lewisi*) assigning two of Etheridge's 1919 species (*carolinensis* and *johnstoni*) to his second new genus.

Subsequent references to this faunule have relied upon Kobayashi's determinations (e.g. Banks, 1962) but no further taxonomic study has been attempted. With the recognition of the biostratigraphic utility of species of *Carolinites* in several parts of the world and revision of *C. bulbosus* by Henderson (1983), still not based on Etheridge's material, a review of the whole faunule has once again become necessary.

Latex casting techniques provide greater morphological detail than was previously available. We have attempted to illustrate as many specimens as possible to provide fuller understanding of each taxon and to avoid misinterpretations based on too few, often deformed specimens.

In the face of relatively poor preservation (see below) we have been fortunate in having available not only the collection of the Tasmanian Museum (prefixed Z) including the type collections of both Etheridge (1883) and Kobayashi (1940) but also two large topotype collections; one is the George Sweet Collection

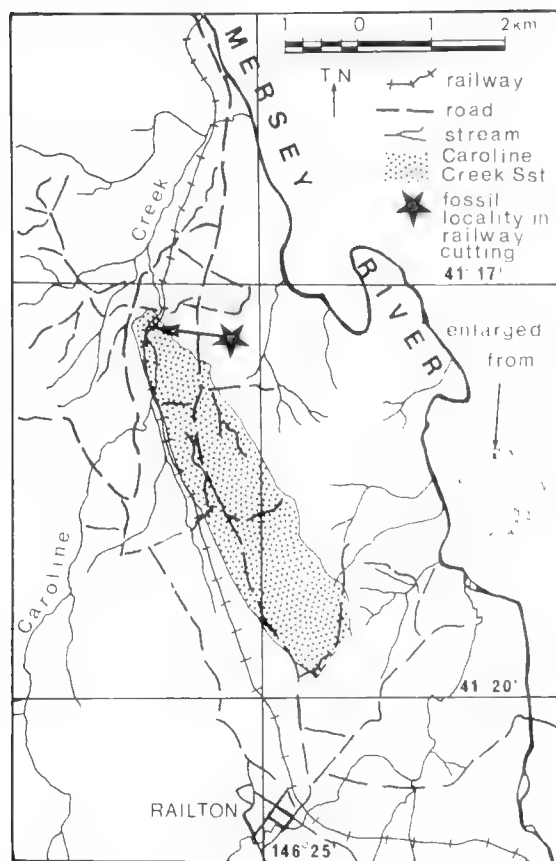


Figure 1. Locality map redrawn from Sheffield 1 mile to 1 inch geological map, Geological Survey of Tasmania.

housed in the Museum of Victoria (prefixed NMVP) and the other in the Australian Museum, Sydney (prefix AMF) acquired by exchange with the Tasmanian Museum probably on the initiative of R. Etheridge Jr.

We are thankful to Dr M. R. Banks, University of Tasmania, Mr D. R. Gregg, Tasmanian Museum, and Dr A. Ritchie, Australian Museum for the loan of or for locating specimens. We thank Penny Clark for printing the photographs from negatives by the senior author, Annette Jell for curatorial assistance and Heather Martin for typing the manuscript.

Age of the faunule

Although originally thought to be of Cambrian age (Etheridge, 1883) Kobayashi (1936,

1940) and subsequent authors recognised their Early Ordovician age. The faunule as here revised contains:

Etheridgaspis carolinensis (Etheridge, 1919)

Tasmanocephalus stephensi (Etheridge, 1883)

Carolinites tasmaniensis (Etheridge, 1919)

Parabasilicus ? *lewisi* (Kobayashi, 1940)

and *Protoencrinurella* ? *subquadrata* (Kobayashi, 1940)

The first two listed species are not known from outside Tasmania and the last two listed species are too poorly known to be useful for precise correlation, although *Protoencrinurella* in association with *Carolinites* may have some significance (see below). Fortey (1975) has shown the utility of species of *Carolinites* for biostratigraphic subdivision of the Arenig and Llanvirn of Spitsbergen and it seems reasonable to use the same tool for age determination of the Caroline Creek Sandstone faunule.

The synonymy of *C. tasmaniensis* (see below) including *C. genacinaca nevadensis* Hintze, allows direct correlation with the top few metres of the Kirtonryggen Formation and basal 3 m of the Olenidsletta Member of the Valhallfonna Formation. This level was correlated (Fortey, 1976) with the early Arenig *D. deflexus* graptolite zone of the British sequence based on the co-occurring graptolites. Legg (1978) showed *Carolinites* and *Protoencrinurella* first appearing in his fauna 3a so that if this association in the Caroline Creek Sandstone was contemporaneous the same correlation through the early Bendigonian of Victoria to the *D. deflexus* zone of Britain is achieved (Legg, 1978, fig. 7; Skevington, 1963). However, Legg's (1976) *C. bulbosus* material appears conspecific with *C. genacinaca* Ross, 1951.

The only other attempt to correlate this faunule with a particular Arenig zone was by Singleton (in Banks, 1962) who provided a late Arenig age in the zone of *D. hirundo*. He gave no explanation of the basis for this correlation, thus preventing evaluation. However, from the range of *C. tasmaniensis* in Spitsbergen and the allied *C. genacinaca* in Spitsbergen and Western Australia this correlation appears

unreasonable. Unfortunately that dating of the faunule has been followed by some subsequent collators (e.g., Banks and Burrett, 1980, p. 365; Webby *et al.*, 1981) although confusion is apparent in other discussions of its correlation. We are able to conclude that the trilobites described below from the Caroline Creek Sandstone indicate an early Arenig age (i.e. early Bendigonian in the Victorian graptolite sequence or *D. deflexus* zone in the British succession) which is somewhat older than previously thought.

Preservation

The fossils are contained in a ferruginous, fine to medium grained sandstone as internal and external moulds of disarticulated exoskeletal components. There has been some post-depositional deformation of most specimens, the amount depending on the orientation in the bedding plane. Although most often showing some skewness in the bilateral symmetry, the deformation may be directly in the sagittal or transverse direction so that measurements of specimens could not be used confidently in comparative studies. Moreover, we believe that it was this distortion which induced Etheridge to recognise a second asaphid species in 1883 and a second species of *Etheridgaspis* in 1919 and Kobayashi (1940) to recognise a second species of *Carolinites*.

The coarseness of the matrix has in most cases allowed penetration of latex into pore spaces at the mould surface so that the latex cast appears to be finely pustulose. However, in most cases the very irregular nature of the pustules makes it obvious that they are not of biological origin. The tubercular ornament of *E. carolinensis* is evident on internal moulds, so this, and the terrace lines on *Tasmanocephalus*, are clearly exoskeletal ornament.

The relatively coarse matrix and disarticulated exoskeletal fragments, and endemic nature of most of the species suggest a fairly high energy and nearshore (respectively) environment of deposition.

Systematic palaeontology

Terminology follows Harrington, Moore and Stubblefield (1959) as far as possible; glabella in-

cludes occipital ring; all dimensions in the sagittal or exsagittal direction are discussed in terms of length and all dimensions in the transverse direction are discussed in terms of width (for example the anterior cranial border whose sagittal dimension is often important in specific description is described in terms of long or short in our terminology). The state of preservation of the fossils removes any confidence in the use of any biometrics so no measurements or reconstructions are included in the descriptions; sizes of individuals are indicated in the explanations of plates and most distinguishing characters are not measurements.

Class Trilobita

Family Hystricuridae Hupe, 1953

Etheridgaspis Kobayashi, 1940

Type species (by original designation):
Ptychoparia ? carolinensis Etheridge, 1919.

Diagnosis: Hystricurids with rounded glabellar anterior, almost parallel-sided glabella; well-impressed pit-like 1p glabellar furrow isolated from axial furrow; shallow 2p glabellar furrow low at axial furrow; preglabellar field shorter than short uniform anterior border; palpebral lobe wide, defined by well-impressed palpebral furrow, situated level with midlength of glabella, becoming longer with growth; librigena with high eye socle, elevated rear area of genal field and strong genal spine. Pygidium transverse; axis of four rings and long terminus reaching border furrow; pleural and interpleural furrows impressed; border narrow, poorly differentiated, convex in section.

Remarks: *Etheridgaspis* was placed by Kobayashi (1940) in the Solenopleurinae along with *Hystricurus* Raymond, 1913 but Henningsmoen (in Harrington *et al.*, 1959) was unable to assign it to an order or family. Important similarities with *Hystricurus* and other members of the Hystricuridae make assignment to that family quite likely. Structure of the anterior of the cranidium, size, shape and position of the palpebral lobe, shape of posterior cephalic limb, impression of pleural and interpleural furrows on pygidium and structure

of pygidial border all suggest relationship with the Hystricuridae. The major distinguishing feature is the well-impressed 1p glabellar furrow and distinct 2p furrow but it should be noted that several lineages thought to have begun in the Hystricuridae (Chatterton, 1971; Fortey & Owens, 1975) involved definition and then deepening of the glabellar furrows. *Omuliovina* Chugaeva, 1962 (type species *O. mira* Chugaeva, 1962) appears superficially similar to *Etheridgaspis* but is clearly distinguished by its lack of a preglabellar field, faint glabellar furrows, its entirely different palpebral structure in particular the course of the palpebral furrow, and its wide concave pygidial border. If this similarity has any phylogenetic basis it could be used in support of the suggestion by Fortey & Owens (1975) that the Bathyuridae, where *Omuliovina* is placed, may have evolved from the Hystricuridae.

In the absence of a clear understanding of a lineage beyond *Etheridgaspis* we assign it to the Hystricuridae but recognise the difficulty of expanding the family concept to include forms with well-impressed glabellar furrows, which may ultimately make diagnosis of the family impossible and force *Etheridgaspis* out.

***Etheridgaspis carolinensis* (Etheridge, 1919)**

Plate 14, figures 1-15; plate 18, figure 15;
text-fig. 2

- 1883 *Conocephalites stephensi* Etheridge, pl. 1, fig. 3 and librigena in fig. 2 (NOT pl. 1, figs 1, 2).
- 1883 (?) *Conocephalites* sp. Etheridge, pp. 156, 162, pl. 1, figs 8, 9, 11.
- 1883 (?) *Conocephalites* sp. Etheridge, p. 157, 162, pl. 1, fig. 10.
- 1888 *Conocephalites* sp. indet. Johnston, p. 37, pl. 1, figs 7, 10, 11, 16.
- 1888 *Conocephalites stephensi* Etheridge; Johnston, pl. 1, fig. 14 (NOT figs 3, 4).
- 1919 *Ptychoparia* (?) *carolinensis* Etheridge, p. 391.
- 1919 *Ptychoparia* (?) *johnstoni* Etheridge, p. 392.
- 1940 *Etheridgaspis carolinensis* (Etheridge); Kobayashi, p. 71, pl. 12, figs 10, 11.
- 1940 *Etheridgaspis johnstoni* (Etheridge); Kobayashi, p. 72, pl. 12, figs 12-14.
- 1940 *Carolmites bulbosa* Kobayashi, pl. 12, fig. 7 (NOT fig. 6).

Lectotype (designated herein): Z1385 the incomplete cranidium figured by Etheridge (1883, pl. 1, figs 8, 9) and herein (Text-fig. 2A, B).

Other material: The specimens of both *E. carolinensis* and *E. johnstoni* figured by

Etheridge (1883) and Kobayashi (1940) as well as some 40 or 50 disarticulated cranidia, librigenae, and pygidia in the Sweet collection and in the Australian Museum Collection.

Diagnosis: As for genus.

Description: Cranidium of low convexity with glabella standing above abaxially rising cheeks; glabella longer than wide (but exact shape uncertain as all cranidia exhibit some post depositional distortion and an undistorted specimen could not be recognised), with straight only slightly forwardly converging lateral margins, with well-rounded anterior, with broad median ridge and evenly sloping sides down to the axial furrow, with two pairs of lateral glabellar furrows; furrow 1p very distinctive, isolated from axial furrow, pit-like on internal moulds but slightly elongate oblique to the axis on the external surface; furrow 2p joining the axial furrow, narrow and relatively indistinct; lobes 1p and 2p of equal length but with frontal lobe occupying nearly half glabellar length; occipital furrow well-impressed, of uniform length, transverse; occipital ring of uniform length, as long as lobe 1p, without median node; preglabellar field very short, of variable length due to distortion after burial; anterior border furrow well-impressed, as long as anterior border, of uniform length; anterior border short, convex, gently arched both forward in dorsal view and upwards in anterior profile, of uniform length; fixigenae narrow (approximately as wide as occipital ring length), rising up abaxially; palpebral lobe short, wide (as wide as interocular cheek), with arcuate abaxial margin but approximately exsagittal adaxial margin defined by palpebral furrow, convex in anterior profile, raised above cheek; palpebral furrow broad, shallow, but distinct, in exsagittal line, finishing forward against a very indistinct eye ridge, continuing posteriorly behind lobe into broad librigenal furrow beneath eye; posterior cephalic limb short and wide, projecting beyond palpebral lobes, occupied mainly by long posterior border furrow; posterior border short, of uniform length except adaxially (tapering to axial furrow); facial suture diverging gently forward from the palpebral lobes,

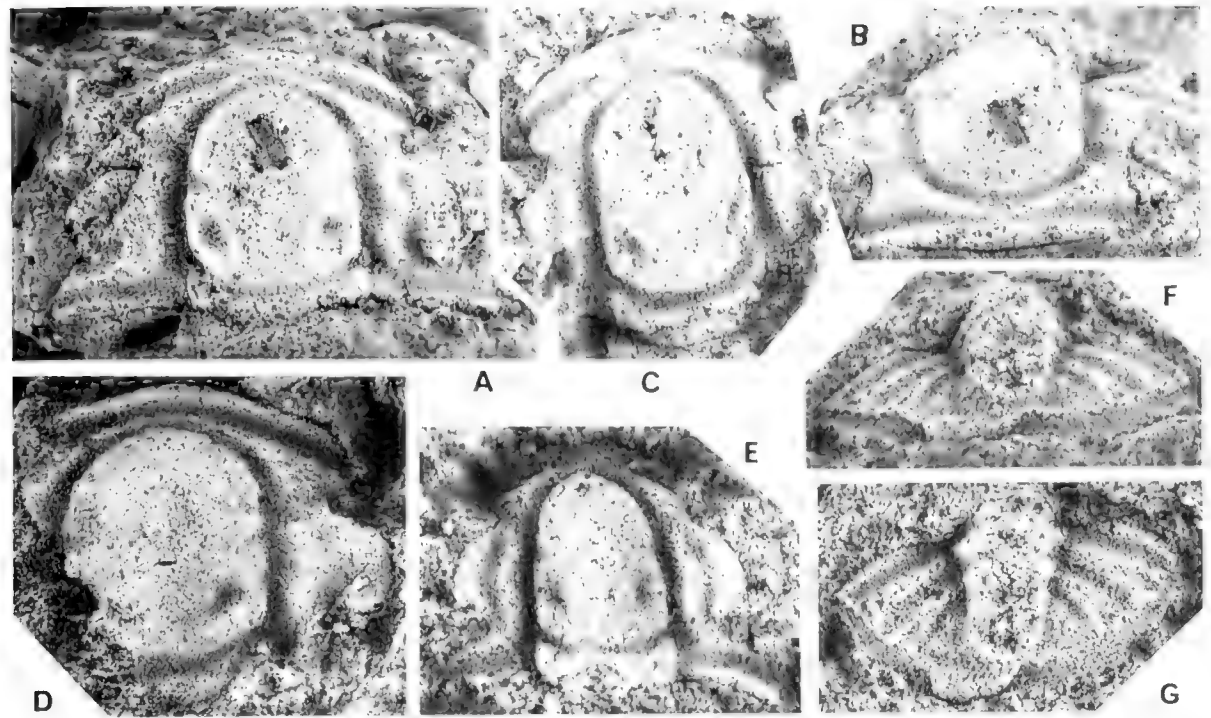


Figure 2. *Etheridgaspis carolinensis* (Etheridge, 1919). All internal moulds. A, B, dorsal and anterior oblique views of lectotype cranidium Z1385, $\times 4$. (Figured by Etheridge, 1883, pl. 1, figs 8, 9). Matrix has been prepared away to expose posterior cephalic limbs. C, cranidium Z1386, $\times 4$. (Figured by Etheridge, 1883, pl. 1, fig. 10). D, cranidium Z1380D, $\times 4$. E, cranidium Z146A, $\times 6$. (Figured by Kobayashi, 1940, pl. 12, fig. 12). F, G, posterior and dorsal views of pygidium Z146B, $\times 5$. (Figured by Kobayashi, 1940, pl. 12, fig. 13).

straight for the short distance to the anterior border then turning adaxially in rather angular change of direction before crossing border diagonally over a short distance. Librigena with high convex visual surface attached; visual surface sloping forward, very short and globular in juveniles but more elongate with ends less curved in larger specimens, with wide shallow furrow running beneath it on librigena; genal field highest just behind eye, sloping both abaxially and anteriorly with base of visual surface sloping at same angle as genal field, extremely narrow anteriorly, widest along posterior margin, with posterior margin transverse along facial suture and including part of posterior border furrow abaxially; lateral border furrow wide, well-impressed, with marked shallowing posteriorly near base of genal spine; border convex, of uniform width, with terrace lines near margin, extended posteriorly into strong

genal spine of approximately half length of librigena; doublure extending forward of genal field indicating a normal ptychoparioid rostral suture pattern.

Pygidium transverse, with axis strongly convex and standing high above pleural fields; axis of three clearly defined rings and posteriorly rounded terminus twice as long as each ring, extending to edge of border furrow; tapering only gently posteriorly; pleural area crossed by well-impressed pleural furrows becoming more posteriorly directed towards the rear, with each rib bearing a shallow but distinct interpleural furrow; border furrow ill-defined; border defined more by lack of pleural furrows than by border furrow, flat on top but with convex roll over margin, with slight posteromedial invagination.

Ornament over entire exoskeleton, except for furrows, consisting of fine granules spread

sparsely and a dense set of fine pustules in between.

Remarks: Although both Etheridge (1883, 1919) and Kobayashi (1940) recognised two species of this genus from the one locality we consider that the variation in width of glabella, in length of prelabellar field and anterior border, and in width of cheeks is all due to post depositional distortion which affected almost every specimen examined from this locality. This distortion is so common that no confidence can be attached to measurements of relative proportions of the glabella. The variation in these features is not due to growth, as small cranidia (e.g., Pl. 14, fig. 11) may have short wide glabellae of similar proportions to larger ones. Another feature of note is the variation in the degree of arching of the anterior margin of the cranidium when viewed from above—this variation which is also the result of distortion indicates that anterior border and preglabellar field have been distorted and should not be used (especially their dimensions) for specific discrimination. For these reasons we are convinced that this single locality yields remains of only one species of *Etheridgaspis*.

Family TELEPHINIDAE Marek, 1952

***Carolinites* Kobayashi, 1940**

Type species (by original designation): *Carolinites bulbosus* Kobayashi, 1940 = *Carolinites tasmaniensis* (Etheridge, 1919).

Remarks: This genus has been the centre of considerable study over the last 35 years with the most exhaustive treatment by Fortey (1975). This restudy of the type species serves to clarify its synonymy; the generic concept and affinities have been adequately covered previously.

***Carolinites tasmaniensis* (Etheridge 1919)**

Plate 15, figures 1-17

- 1883 'Fragmentary head shield, allied to *Bathyrurus*' Etheridge, p. 157, pl. 1, fig. 12.
- 1888 *Bathyrurus* (?) sp. Johnston, p. 37, pl. 1, fig. 19.
- 1919 *Ptychoparia* (?) *tasmaniensis* Etheridge, p. 392.
- 1940 *Carolinites bulbosa* Kobayashi, p. 70, pl. 12, fig. 6 (NOT pl. 12, fig. 7).
- 1940 *Carolinites quadrata* Kobayashi, p. 70, pl. 12, figs 8, 9.
- 1940 *Carolinites* (?) *tasmanensis* (sic) Etheridge; Kobayashi, p. 71.

- 1953 *Carolinites genacinaca nevadensis* Hintze, p. 146, pl. 20, figs 3-6.
- 1970 *Carolinites* ex gr. *genacinaca* Ross; Bursky, p. 103, pl. 6, fig. 10.
- 1975 *Carolinites genacinaca nevadensis* Hintze; Fortey, p. 115, pl. 38, figs 4-13.
- NOT
- 1976 *Carolinites bulbosa* Kobayashi; Legg, p. 5, pl. 1, figs 20, 25, 26, 29, 30, 34.
- NOT
- 1983 *Carolinites bulbosus* Kobayashi; Henderson, p. 146, fig. 1A-H, K.

Material: Holotype Z1387. The material of Kobayashi (1940) as well as the specimens figured herein and a number of others in the Sweet Collection and the Australian Museum Collection are all available topotypes.

Diagnosis: Member of *Carolinites* with baculae of variable size but always smaller than in other known species; glabella broadly rounded anteriorly; fixed cheeks of variable width but generally narrow. Librigena with strongly inflated band subparallel to base of eye; genal spine not longer than librigenal length, straight and in exsagittal line, not expanded at base, arising from near posterior of cheek. Pygidium with two transaxial furrows well impressed and a third poorly impressed; border furrow well impressed; pleural areas narrow and protruding.

Description: Glabella subquadrate, with greatest width generally about 0.25 of length from anterior, forward expansion extremely weak, rounded anterolateral corners and broadly rounded to slightly flattened anterior, without lateral glabellar furrows; occipital furrow deep, transverse, short; occipital ring flat in lateral profile, of uniform length except laterally, shortening slightly and turning forward laterally to run across axial furrow as low ridge into posteroproximal corner of fixigena at baccula; baculae of variable size but always quite small; fixigena triangular in shape, flat to slightly sloping laterally, narrow; palpebral lobe narrow, defined by well impressed palpebral furrow with marked ridge on its adaxial edge; posterior border furrow well impressed, shorter than posterior border, of uniform length. Librigena with large bulbous visual surface, narrow, with distinct furrow beneath eye then prominent ridge subparallel to margin of eye just abaxial to the furrow and disappearing for-

ward where border and eye converge, with genal spine no longer than librigena itself arising from posterior part of librigena and lying almost in an exsagittal line, with lower margin of visual surface at low angle to plane of genal spine and posterior border (eye apparently tilted forward).

Pygidium convex with axis standing high above pleural areas; axis crossed by two well impressed transaxial furrows and a third poorly impressed transaxial furrow, consisting of three rings and short ill-defined terminus with steep posterior slope; pleural area narrow, of almost uniform width throughout, crossed by three distinct pleural furrows, markedly convex, with prominent protruberance from posterior rib; border furrow well impressed, overhung by pleural areas so not visible in dorsal view except posteriorly; border narrow, uniform.

Remarks: Examination of the specimen figured by Etheridge in 1883 (pl. 1, fig. 12) and later (1919) named *Ptychoparia* ? *tasmaniensis* showed that it was conspecific with Kobayashi's *Carolinites bulbosa* and had been misrepresented in the original line drawing. The reason was probably that he drew the edge of the border at the edge of the piece of rock and then misinterpreted the border (which was actually inside but parallel to the edge of the rock) as a preglabellar field—a natural mistake after just drawing three cranidia of *Etheridgaspis carolinensis* where this arrangement occurs. Significantly the glabella was correctly shown with a subtle forward expansion and this feature alone confirms that the illustration is of a *Carolinites* specimen among the species now known from the site. The holotype is figured herein (Pl. 15, fig. 7) after preparation to remove more of the external mould on the right cheek. Kobayashi (1940, p. 71) clearly did not look at the holotype but discussed Etheridge's figure only. The palpebral lobes were not illustrated by Etheridge and Kobayashi's comment on the size of the eye is not applicable when the extra preparation exposes its full extent. His reference to a broad free cheek is an error as he had no free cheek available and probably meant fixed cheek; the fixigena is of comparable width to that of other cranidia of this species which have narrower fixigena than other

species of the genus. Convexity of the glabellar anterior is not an admissible feature in this collection of variously distorted cranidia. Examination of some 50 topotype cranidia shows that only one species of *Carolinites* is present, that being Etheridge's *C. tasmaniensis* with *C. bulbosus* and *C. quadratus* of Kobayashi as junior subjective synonyms.

Fortey (1975, p. 102) outlined the diagnostic features of *G. genacinaca nevadensis* Hintze as small bacculae barely indenting the base of the glabella, relatively narrow fixigenae for the genus, straight genal spine originating posteriorly on the librigena, an inflated band parallel to the base of the eye on the librigena, and only two pygidial axial rings clearly defined by deep transaxial furrows. He stated that the inflated librigenal band was perhaps the most diagnostic of all and we agree fully. *Carolinites tasmaniensis* has all these attributes and must be considered the senior synonym of *C. genacinaca nevadensis*. The Australian material identified as *C. bulbosus* by Legg (1976) and Henderson (1983) has the glabella more indented by bacculae, has wider fixigenae, and the genal spines are well advanced on the librigenae. All of these features suggest *C. genacinaca* Ross, 1951 as noted by both those authors. The librigena of Legg (1976, pl. 1, fig. 29) does appear to have the inflated band but it is not clear if all his material is from one horizon or not and a more detailed study would be necessary to determine whether or not more than one species is represented in Legg's *C. bulbosus*.

Family MISSISQUOIIDAE Hupe, 1955

The family was restricted (Shergold, 1975; Ludvigsen, 1982) to include only *Missisquoia* Shaw, 1951 and *Parakoldinioidia* Endo, 1937 but Fortey (1983) considered these two genera as synonymous. He separated *Lunacrania* Kobayashi, 1955 within the family on the basis of "minute palpebral lobes well removed from the glabella". The cheeks in his species of *Lunacrania* are narrower relative to the width of the glabella than in *P. depressa* Stitt, 1971 where the interocular cheek is also only slightly narrower than the glabella. Moreover, Fortey (1983, p. 196) acknowledged narrower fixed

checks within *Lunacrania* so the only generic taxobase could be size of the palpebral lobes. This hardly seems a satisfactory generic taxobase when the palpebral structure of his (Fortey, 1983, pl. 25, figs 5 and 9) specimens attributed to *Parakoldinioidia* and *Lunacrania*, respectively, are compared; the length appears to be little different and the width, if different, would be no more than a specific taxobase. As the characters quoted by Fortey (1983) appear to grade through the species assigned to *Parakoldinioidia*, *Lunacrania* and *Missisquoia* and as no other features present themselves as generic taxobases we consider that the senior synonym, *Parakoldinioidia*, may encompass all the species of the Missisquoiidae considered by Shergold (1975), Ludvigsen (1982) and Fortey (1983). However, no diagnosis has been offered since 1955. There do appear to be good reasons for this oversight because each family character is found in genera outside the family and the pygidia included seem to have no unifying features. Perhaps most diagnostic of the family are the transverse (or almost so) lateral glabellar furrows, the anteromedian glabellar notch, and the posteriorly situated palpebral lobes. The marginal pygidial spines are not considered to be more than generically significant, if that, because production of a macropleural segment in the pygidium appears to have been a relatively simple process occurring in a number of trilobite families. *Tasmanocephalus* may be regarded as having descended from *Parakoldinioidia*, most probably from the *M. depressa* side of the genus with accompanying development of a macropleural segment in the pygidium and reduction in size and posterior migration of the palpebral lobe.

No known trilobites appear to have descended directly from *Tasmanocephalus*. However, a comparison of *T. stephensi* with species of *Perischoclonus* Raymond, 1925 (see Whittington, 1963, pl. 22) and *Raymondaspis* Přibyl in Přibyl & Přibyl, 1949 (see Whittington, 1965, pls 55-59) prompts us to conclude that *Tasmanocephalus* may be an offshoot from an evolutionary lineage leading from *Parakoldinioidia* through *Perischoclonus* to *Raymondaspis* or at least from the Missisquoiidae to the Styginidae. Particularly significant in

Perischoclonus and *Raymondaspis* are isolation of 2p and 3p glabellar furrows from the axial furrow with markedly divided eye ridges reaching axial furrow at glabellar lobe 3p (Whittington, 1965, pl. 22, figs 4, 6), the anteromedian notch and small posteriorly-situated palpebral lobes (Whittington, 1963, pl. 22, figs 2, 4 and 1965, pl. 56, figs 6-10), wide cranial border constricted in front of glabella, low ridge running from the anterolateral corners of the glabella into fixigena (Whittington, 1963, pl. 22, figs 1, 4 and 1965, pl. 58, fig. 4), and structure of the hypostome with long almost exsagittal median furrows on the median body (Whittington, 1965, pl. 55, figs 2, 7, 8). The forward expanding glabellae of *Perischoclonus* and *Raymondaspis* are a progression from the subrectangular to slightly expanding glabellae in *Tasmanocephalus* and subrectangular or tapering glabellae of *Parakoldinioidia*. Development of styginid morphology involves progressive effacement of furrows and widening of the border most noticeably in the pygidium but the juvenile pygidium of *Raymondaspis* (Whittington, 1965, pl. 57, fig. 10) has pleural and interpleural furrows well-impressed and the pleural ribs are extended into short spines, much as in *Parakoldinioidia*. The postaxial median ridge of *P. depressa* (Stitt, 1971, pl. 8, fig. 8) is present in *Raymondaspis* but is broader in *Perischoclonus* and less distinct in *Tasmanocephalus*. With sufficient common features to link these four genera we suggest that evolution from the Missisquoiidae to the Styginidae took place on the North American craton with *Tasmanocephalus* representing a lineage that migrated to Australia during the late Tremadoc.

This phylogenetic placement for *Tasmanocephalus* lends weight to the arguments of Ludvigsen (1982, p. 119) that out of the Leiestegioidea the Missisquoiidae gave rise to the Styginidae. Lane & Thomas (1983, p. 155) preferred to derive the Styginidae from the Corynexochida without investigating Ludvigsen's proposal closely. However, features quoted in support of their alternative, namely a postaxial ridge on the pygidium, an anteriorly expanding glabella extending far forward and

the type of hypostome are all known in *Parakoldinioidia* and/or *Tasmanocephalus*. The only other feature quoted, width of the rostral plate, seems to us less important than the attitude of the connective sutures and the width relative to hypostomal width. In the Corynexochida connective sutures are normal to the margin whereas in Missisquoiidae and Styginidae they are markedly oblique across the doublure. A number of the rostral plates attributed to their Scutelluina and figured (Lane & Thomas, 1983, text-fig. 3) recently are narrow if measured posteriorly and indeed styginid rostral plates narrower than the hypostome are not uncommon (e.g. Harrington *et al.*, 1959, figs 275, 276. To our knowledge the rostral plate is always wider than the hypostome in the Corynexochida.

The inadmissible nature of these criteria apart, the Corynexochida lack the anteromedian glabellar notch of the Missisquoiidae and early Styginidae, a feature that, although known in several trilobite lineages in different superfamilies, could be confidently expected in the ancestral stock, even if only in the early growth stages, of a family like the Missisquoiidae where it is universally present. Moreover, the Corynexochida in general have relatively long palpebral lobes contrasting with the generally short palpebral lobes of the Missisquoiidae, Styginidae, and derivatives of the latter family. It seems most likely that the one or two species whose palpebral lobe length is at odds with this generalisation have derived that character along offshoots from the main development of the groups.

Homeomorphous similarities between Corynexochida and Missisquoiidae, Styginidae etc., particularly in the glabella, are considered to result from development of the same feeding habit and therefore the same anterior alimentary specialisations in two separate stocks of trilobites. In categorising trilobite morphologies based on inferred feeding habits Jell (1981) proposed the dorypygid morphology with bulbous, anterolaterally expanded glabella reaching anterior border furrow; large pygidium often spinose; fewer than 10 thoracic segments. The Corynexochida, early Styginidae and a number of Leiestegioidea including

Missisquoiidae exhibit this broad morphology but phylogeny is established on other features.

***Tasmanocephalus* Kobayashi, 1936**

Type species (by original designation): *Conocephalites ? stephensi* Etheridge, 1883.

Diagnosis: Glabella subrectangular, with three pairs of well-impressed almost transverse lateral furrows, with 1p furrow expanded posteriorly at adaxial end, with distinct invagination (probably a muscle attachment site) anteromedially; preglabellar field absent; anterior border shorter in front of glabella; palpebral lobes short, situated well away from glabella and well to posterior opposite glabellar lobe 1p; rostral plate narrow; librigena with long flat genal spine deflected laterally, with border furrow extending onto genal spine. Pygidium with long axis of seven or more rings plus a long terminus reaching border furrow; pleural areas with pleural and interpleural furrows impressed; border distinct, narrow, defined by very shallow furrow; pair of strong marginal spines arising from border adjacent to end of fourth pygidial segment.

Remarks: *Tasmanocephalus* is very similar to *P. depressa* in cranial features such as glabellar furrows, glabellar shape and convexity, anteromedian glabellar notch, low ridge from anterolateral corners of glabella, structure of the border, short wide posterior cephalic limb, and structure of the hypostome with long almost exsagittal median furrow. However, position and structure of the palpebral lobes, course of the eye ridge and structure of the pygidial border and marginal spines are sufficient to separate these two genera. *Raymondaspis* is distinguished by its glabellar shape, less distinct glabellar furrows, general effacement of all furrows particularly on the pygidium, and kidney-shaped palpebral lobe close to the glabella. *Perischoclonus* may be distinguished by its lack of an anteromedian glabella notch, its less prominent eye ridges, its smaller 2p and 3p glabellar furrows, its better impressed pleural furrows, and its lack of marginal pygidial spines. Hintze (1953, p. 227) claimed 'considerable resemblance' between his *Pseudoolenoides* and *Tasmanocephalus* but it

would appear that his genus, if related at all, is related to the *P. stitti* side of *Parakoldinioidia* with the convex glabella having furrows low on the side, narrow convex border, and more elongate subtriangular pygidium. These features, among others, distinguish it from *Tasmanocephalus*.

***Tasmanocephalus stephensi* (Etheridge, 1883)**

Plate 16, figures 1-14; plate 18, figures 8-12; text-fig. 3

- 1883 *Conocephalites* ? *stephensi* Etheridge, p. 153, pl. 1, figs 1, 2. (NOT pl. 1, fig. 3 or librigena in fig. 2).
 1883 *Dikelocephalus tasmanicus* Etheridge, p. 155, pl. 1, fig. 4.
 1888 *Conocephalites stephensi* Etheridge; Johnston, p. 37, pl. 1, figs 3, 4 (NOT librigena in 4).
 1888 *Dikelocephalus tasmanicus* Etheridge; Johnston, p. 37, pl. 1, fig. 8.
 1919 *Crepicephalus tasmanicus* (Etheridge); Etheridge, p. 390.
 1936 *Tasmanocephalus stephensi* (Etheridge); Kobayashi, p. 180, pl. 20, figs 11-14; pl. 21, figs 2-4. (NOT pl. 21, fig. 1 or the librigena in fig. 2).
 1940 *Tasmanocephalus stephensi* (Etheridge); Kobayashi, p. 69, pl. 12, figs 1-4.
 1940 Free cheek gen. et sp. indet. Kobayashi, pl. 12, fig. 15.
 1940 *Asaphellus lewisi* Kobayashi, pl. 12, fig. 18. (NOT pl. 12, figs 16, 17, 19).

Lectotype (designated herein): Z1378 the damaged cranidium figured by Etheridge (1883, pl. 1, fig. 1) and herein (Pl. 16, fig. 12).

Diagnosis: As for genus.

Description: Moderately large trilobite of fairly low convexity. Cranidium subrectangular with only posterior limbs projecting beyond this shape; glabella also subrectangular, between 0.3 and 0.5 times as wide as long, appearing to expand very gently forward in some specimens to a widest point at the posterior of the frontal lobe, anterior truncated to very broadly convex forward, with three pairs of lateral glabellar furrows and distinct anteromedian indentation in glabella; furrow 1p with deep pit near adaxial end, possibly forked adaxially, angled slightly behind transverse line from axial furrow adaxially, well-impressed at axial furrow; furrow 2p also with deeper pit adaxially, shallowing at axial furrow and appearing in some individuals to be isolated from axial furrow, running transversely; furrow 3p closer to axial furrow than 2p, shallower than 2p, almost isolated

from axial furrow, transverse; lobes 1p, 2p, and 3p almost equal in length, lobe 1p longest abaxially, 2p longest adaxially; frontal lobe almost twice as long as any of others; occipital furrow well impressed, with marked apodemes laterally, curving forward laterally but transverse medially; occipital ring shortest laterally behind apodemes, flat to gently convex in lateral profile; axial furrow well-impressed, with marked pit anteriorly in front of eye ridge but behind strong trunk issuing from anterolateral corner of glabella just behind border furrow; eye ridge prominent, running into posterior corner of frontal glabellar lobe as low ridge across axial furrow, consisting of two parallel trunks widely separated by distinct furrow through medial part of its extent but unseparated at ends; palpebral lobe short, highly arcuate, elevated around outer edge, elevated above cheek, situated opposite lobe 1p; fixed cheeks rising up abaxially, but with palpebral lobe sharply elevated above cheek, with distinct caecal network of fine ridges running forward from eye ridge; posterior cephalic limb short, wide but only half width of interocular cheek; posterior border furrow well-impressed, as long as posterior border, occupying most of posterior cephalic limb; preglabellar field absent; anterior of glabella encroaching into posterior of anterior border; anterior border short in front of glabella, nearly twice as long laterally, with fine terrace lines marginally; anterior border furrow short in front of glabella but slightly longer and with gently tapering sides laterally; facial suture diverging only very slightly forward in gentle curve, crossing border diagonally, transverse behind palpebral lobe then meeting posterior margin in low angle. Librigena with strong genal spine and sloping steeply laterally; eye socle high, with curved upper margin in horizontal plane, with distinct furrow beneath it above genal field; genal field sloping down laterally and posterolaterally to genal angle; border furrow well-impressed anteriorly, shallowing a little posteriorly but well-impressed again at genal angle and along posterior edge, extending a short distance and then fading out along genal spine, situated closer to adaxial side of genal spine; border flat

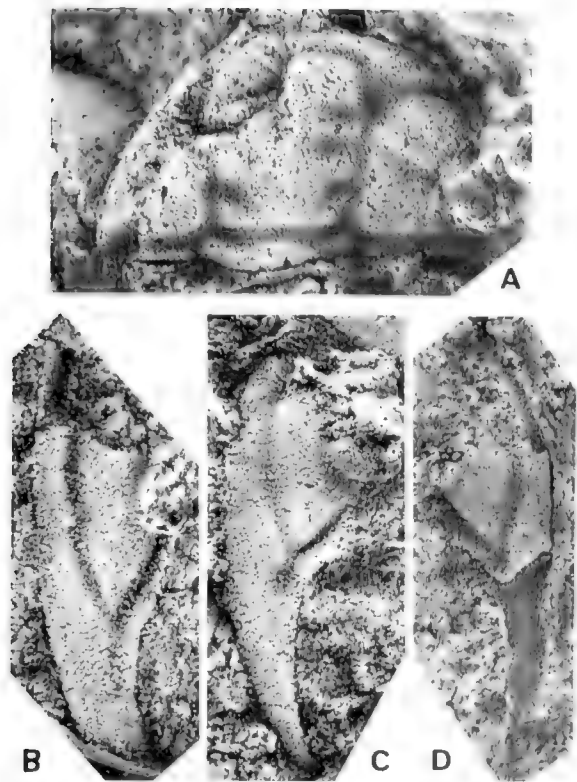


Figure 3. *Tasmanocephalus stephensi* (Etheridge, 1883). A, internal mould of cranidium Z1379, $\times 4$, (Figured by Etheridge, 1883, pl. 1, fig. 2 and by Kobayashi, 1936, pl. 21, fig. 2). The librigena illustrated by Etheridge is evident but at a steeper angle to the cranidium than originally depicted—see explanation in text. B, latex cast of librigena showing forward extension of the doublure, NMVP71239, $\times 4$. C, latex cast of librigena NMVP71240, $\times 3$. D, internal mould of librigena showing forward extension of the doublure NMVP71241, $\times 3$.

to gently convex, sloping down to margin, becoming wider and flatter from near midlength of librigena to genal spine, short and convex posteriorly inside genal angle; genal spine nearly twice length of librigena, comparatively flat and wide, becoming more rounded posteriorly; doublure narrow but extending well forward adaxial of genal field so rostral plate must have been quite narrow.

Hypostome subquadrate, with convex median body; anterior margin transverse, with strong medial depression; anterior wings short turned strongly dorsally; median body with slightly inflated anterior lobe and short

posterior lobe, divided by strong median furrow, lateral borders widened posteriorly, sloping ventrally away from border furrow; border furrow broad laterally, with two distinct and elongate pits—one at posterior of anterior lobe of median body and other laterally behind posterior lobe, short and sharp posteriorly; posterior border short, tapering to sagittal line; posterior margin broadly arched forward over sagittal line.

Pygidium approximately semicircular, with pair of marginal spines; axis of seven rings and a long terminus probably containing several more rings, tapering evenly posteriorly to rounded posterior at border furrow, with apodemal pits evident laterally in transverse transaxial furrows of internal moulds; axial rings becoming shorter and increasingly poorly defined posteriorly; pleural areas with well-impressed long pleural furrows having broad U-shaped, section, with on each pleural rib well-impressed interpleural furrow having short almost V-shaped section, with furrows at increasing angle to transverse line towards posterior, becoming less distinct posteriorly; border furrow distinct but poorly impressed, of uniform width throughout; border narrow and uniform, with marginal terrace lines, weakly convex and downsloping to margin; marginal spines broadly based, tapering rapidly to point, issuing from border opposite pleural furrow of fourth pygidial segment. Surface of exoskeleton without ornament.

Remarks: Etheridge (1919) and Kobayashi (1940) both concluded that the cranidia and pygidia which they first thought belonged to different species should be united as herein. Comparison with *Parakoldinioidia* above, further suggests the assignment of these exoskeletal parts to the one species. Close examination of the syntype (Etheridge, 1883, pl. 1, fig. 2) thought to have its librigena slightly dislodged but essentially in place, shows that the free cheek is in fact not in place; it is back to front and actually belongs to *Etheridgaspis carolinensis*. It is also clear that the librigena (Etheridge, 1883, pl. 1, fig. 3) assigned to this species belongs to *Etheridgaspis carolinensis*; this is deduced from the length of the palpebral lobe compared to the visual surface of the

larger specimens, from the ornament, and from the length of the posterior cephalic limb compared to the length of facial suture on librigena.

Family ASAPHIDAE Burmeister, 1843

Parabasilius Kobayashi, 1934

Type species (by original designation):

Parabasilius typicalis Kobayashi, 1934.

Parabasilius ? lewisi (Kobayashi, 1940)

Plate 17, figs 1-10; plate 18, figs 13, 14;
text-fig. 4

1883 *Asaphus* sp. a. Etheridge, p. 156, pl. 1, figs 6, 7.

1883 *Asaphus* sp. b. Etheridge, p. 156, pl. 1 fig. 5.

1888 *Asaphus* sp. indet. Johnston, pl. 1, figs 9, 17, 18.

1919 *Bathyrus* (?) spp. Etheridge, p. 392.

1940 *Asaphellus lewisi* Kobayashi, p. 74, pl. 12, figs 16, 17, 19 (NOT fig. 18).

Lectotype (designated herein): Z133, the damaged cranidium figured by Kobayashi (1940, pl. 12, fig. 16) and herein (Pl. 17, fig. 2).

Diagnosis: Member of *Parabasilius* with glabella narrowest at posterior of palpebral lobe, expanding both forward and back quite strongly, with short highly arcuate palpebral lobes projecting a considerable distance laterally, with occipital and posterior border furrows impressed, with strongly forked posterior to hypostome and ridge on outer edge of posterior spine running well onto anterior lobe of median body, without genal spine, with concave border on both cranidium and pygidium, without furrows on pygidial pleural fields, and with low indistinct axis.

Description: Cranidium of moderate convexity, with palpebral lobes elevated above glabella and anterior sloping down to margin; glabella waisted near rear of palpebral lobe, expanding forward to well rounded anterior some distance from border, without furrows, with weak occipital furrow, without a node visible on available specimens; axial furrow weakly impressed, most obvious between palpebral lobes and at posterior margin; preglabellar field as long as border, flat, downsloping; anterior border flat, downsloping to margin, longest sagittally; palpebral lobe short, close to glabella, highly arcuate abaxially, projecting strongly abaxially, highest part of cranidium, flat, without palpebral furrow; facial suture

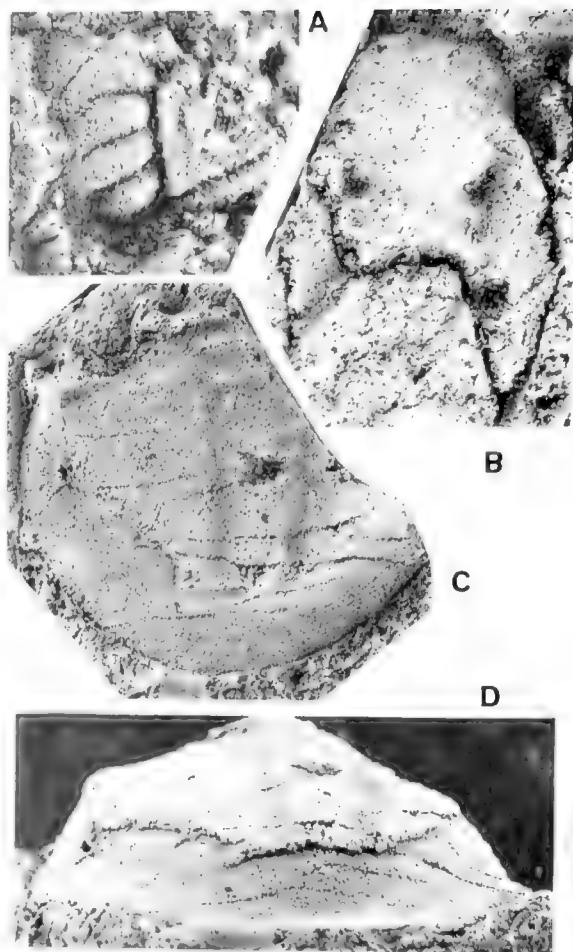


Figure 4. A, *Protoencerinurella* ? *subquadrata* (Kobayashi, 1940), latex cast from partial external mould of cranidium showing forward expanding glabella, AMF65513, $\times 7$. B-D, *Parabasilius* ? *lewisi* (Kobayashi, 1940). B, internal mould of hypostome Z1384, $\times 5$. (Figured by Etheridge, 1883, pl. 1, fig. 7). C, D, dorsal and posterior views of internal mould of damaged pygidium Z1382, $\times 1.5$. (Figured by Etheridge, 1883, pl. 1, fig. 5).

diverging forward gently from palpebral lobes to widest point at border furrow, curving adaxially on border to run parallel to but well inside margin in normal isotelliform manner, almost transverse behind palpebral lobe, turning sharply back distally to meet posterior margin at 90° ; posterior cephalic limb short and wide, with faint posterior border furrow on it. Librigena with low but distinct eye socle above

wide shallow furrow parallel to base of eye; border furrow wide, shallow, virtually disappearing near genal angle along lateral border, entirely absent along posterior border; border gently convex, tapering posteriorly to nothing at genal angle; doublure convex ventrally, tapering strongly to posterior, with distinct terrace lines parallel to margin; genal angle just under 90° , without spine. Hypostome large, with very strongly forked posterior; anterior margin almost transverse, with shallow median depression; anterior wings not greatly expanded, extending strongly dorsally and posteriorly; sharp lateral notch with angular anterior edge of shoulder overhanging notch; shoulder greatly expanded posteriorly into broad flat projection, with sharp ridge along abaxial edge of shoulders running forward up onto anterior lobe of median body; median body with large inflated anterior lobe and short low posterior lobe; median furrow reduced to pair of prominent pits; another pair of shallow pits situated just behind the median furrow near posterior margin (presumably homologous with those often found in the posterior border furrow of hypostomes e.g., in *Asaphopsoides florentinensis* (Etheridge, 1905); border furrow not evident; posterior margin between projections transverse with high marginal downturn.

Pygidium semicircular, of relatively low convexity; axis low, tapering posteriorly to narrowly rounded posterior at inner edge of border furrow, with seven or more indistinct rings; pleural areas without furrows except for well impressed anterior border furrow; articulating facet steep, weakly concave, at low angle to transverse line; border furrow distinct but expressed only as a change of slope from pleura to border; border flat to slightly downsloping, tapering forward; doublure wide, tapering forward, with small notch in inner edge posteromedially to accommodate axis.

Remarks: Assignment of this relatively poorly-known asaphid species is fraught with difficulties and the assignment to *Parabasilicus*, itself a poorly-understood genus (Jaanusson in Harrington *et al.*, 1959), is and will probably remain tentative. The assignment is proposed on the basis of the effacement of the furrows but with the shape of the glabella and axis evi-

dent, and on the structure of the hypostome (cf. Kobayashi, 1934, pl. 41, fig. 3). Other features observable on both Tasmanian and Korean specimens, appear to be within the limits of generic variation. The situation of the palpebral lobes a little further back and lack of genal spines serve as specific taxobases to identify the Tasmanian species.

Kobayashi (1934) dated the Korean *Parabasilicus* as late Llandeilo and Harrington & Leanza (1957) identified the genus in northern Argentina in sediments of Llanvirn age so this Tasmanian occurrence in the early Arenig suggests that the genus may have been longer ranging than originally thought.

Family PLIOMERIDAE Raymond, 1913

Protoencrinurella Legg, 1976

Type species (by original designation): *Protoencrinurella maitlandi* Legg, 1976.

Protoencrinurella ? subquadrata (Kobayashi, 1940)

Plate 18, figures 1-7; text-fig. 4

1940 *Prosopiscus* (?) *subquadratus* Kobayashi, p. 70, pl. 12, fig. 5.

Material: This is a rare species with only the figured specimens and a few other less complete fragments available in the collections. The holotype specimen is mislaid at present but is almost certainly in the collection of the Tasmanian Museum.

Diagnosis: Glabella with straight parallel sides, tending to expand slightly adjacent to frontal lobe, broadly rounded anteriorly; occipital ring elongate medially, tapering to axial furrow; lateral glabellar furrows wide, slit-like, inclined only gently to transverse line as they approach axis; furrow 3p with transverse lateral section then turned posteriorly in adaxial section; small, posteriorly directed fixigenal spine present at genal angle. Pygidium with five pairs of marginal furrows; pleural ribs becoming elongate away from axis then tapering again in free section beyond margin of pygidium; interpleural furrows absent.

Description: Cranidium apparently twice as wide as long (This is not certain as all available specimens seem to be slightly shorter than nor-

mal for the family and may be distorted.); glabella subquadrate, with straight parallel sides or expanding forward adjacent to frontal glabellar lobe, but with occipital ring noticeably narrower than rest of glabella, with broadly rounded anterior, with three pairs of wide slit-like lateral glabellar furrows; glabellar lobes 1p to 3p subequal in length at axial furrow, with 1p tapering adaxially and others of uniform length; furrow 3p with transverse section at axial furrow turning posteriorly and running in a widely convex and posteriorly inclined adaxial section; frontal lobe longer than others; occipital furrow running in anteriorly convex arch, almost meeting with furrow 1p; occipital ring markedly elongate medially, tapering to nothing laterally well inside the lateral margin of the glabella; anterior border short and rim-like; palpebral lobe at high angle to transverse line, of uniform width, curving strongly adaxially and running to axial furrow at posterior of frontal lobe as narrow eye ridge; posterior border becoming elongate abaxially, with short posteriorly directed fixigenal spine at the genal angle.

Pygidium transverse; axis of five rings and short triangular terminus, tapering posteriorly quite strongly; pleural areas crossed by well-impressed pleural furrows curving posteriorly distally and becoming almost exsagittal by fourth and fifth furrows, without interpleural furrows; pleural ribs becoming more elongate laterally towards the margin of pygidium, tapering again as free marginal spines distally; fifth pair of ribs enclosing axial terminus except for single point at posterior margin medially; marginal spines apparently quite short and downturned.

Remarks: Assignment of this poorly-preserved pliomerid species is difficult as some important generic taxobases are not available (e.g. structure of fixigena forward of eye ridge, tips of pygidial pleurae). It is assigned to *Protoencrinurella* on the basis of features which Legg (1976) quoted as distinguishing the genus from its close relatives; these features are possession of palpebro-ocular ridges (Pl. 18, fig. 4), sinuous 3p glabellar furrows (Pl. 18, figs 2-4), and inflated pygidial pleurae (Pl. 18, figs 4, 7). On the other hand the glabella of the Tasma-

nian species is more quadrate than forward expanding and the lengths of the glabellar lobes are somewhat variable (cf. Pl. 18, fig. 2 where they increase in size forward with Pl. 18, fig. 4 where they appear to be of more even sizes). Otherwise there seems to be a reasonable comparison between the two species which may be distinguished by the glabellar differences mentioned above.

References

- BANKS, M. R., 1962. The Ordovician System. *J. geol. Soc. Aust.* 9: 147-176.
- BANKS, M. R. & BURRETT, C. F., 1980. A preliminary Ordovician biostratigraphy of Tasmania. *J. geol. Soc. Aust.* 26: 363-376.
- BURMEISTER, H., 1813. *Die Organisation der Trilobiten*. 148 pp., 4 pls. Berlin.
- BURSKY, A. Z., 1970. Early Ordovician trilobites of central Pai-Khoya. In *Reference papers on the Ordovician in Pai-Khoya, Vaigach Islands and Novaya Zemlya*, Bondarev, V. I., ed., Inst. geol. Arktiki, Leningrad.
- CHATTERTON, B. D. E., 1971. Taxonomy and ontogeny of Siluro-Devonian trilobites from near Yass, New South Wales. *Palaeontographica A* 137: 1-108.
- CORBETT, K. D. & BANKS, M. R., 1974. Ordovician stratigraphy of the Florentine Synclinorium, south-west Tasmania. *Pap. Proc. R. Soc. Tasm.* 107: 207-238.
- CHUGAEVA, M. N., 1962. A new Early Ordovician genus of the Subfamily Hystricurinae from the Kolyma Basin. *Paleont. Zh.* 1962, no. 3.
- ENDO, R., 1937. Description of fossils. *Manch. Sci. Mus. Bull.* 1: 308-369.
- ETHERIDGE, R. JR., 1883. A description of the remains of trilobites from the Lower Silurian rocks of the Mersey River district, Tasmania. *Pap. Proc. R. Soc. Tasm.* 1882: 150-162.
- ETHERIDGE, R. JR., 1905. Trilobite remains collected in the Florentine Valley, west Tasmania, by Mr T. Stephens. *M.A. Rec. Aust. Mus.* 5: 98-101.
- ETHERIDGE, R. JR., 1919. The Cambrian trilobites of Australia and Tasmania. *Trans. R. Soc. S. Aust.* 43: 373-393.
- FORLEY, R. A., 1975. The Ordovician trilobites of Spitsbergen II. Asaphidae, Nileidae, Raphiophoridae and Telephinae of the Valhallfonna Formation. *Skr. norsk Polarinst.* 162: 1-206.
- FORLEY, R. A., 1976. Correlation of shelly and graptolite early Ordovician successions, based on the sequence in Spitsbergen. In *The Ordovician System: proceedings of a Palaeontological Association Symposium, Birmingham, September 1974*, M. G. Bassett, ed., University of Wales & National Museum of Wales, Cardiff, 263-280.
- FORLEY, R. A., 1983. Cambrian-Ordovician trilobites from the boundary beds in western Newfoundland and their phylogenetic significance. *Spec. Pap. Palaeont.* 30: 179-211.
- FORLEY, R. A. & OWENS, R. M., 1975. Proetida—a new order of trilobites. *Fossils and Strata* 4: 227-239.
- HARRINGTON, H. J. & LEANZA, A. F., 1957. Ordovician trilobites of Argentina. *Spec. Publ. Univ. Kans. Dept Geol.* 1: 1-276.

- HARRINGTON, H. J., MOORE, R. C. & STUBBLEFIELD, C. J., 1959. Morphological terms applied to Trilobita. In *Treatise on Invertebrate Palaeontology Part O, Arthropoda 1*, R. C. Moore, ed., Geol. Soc. Amer. & Univ. Kansas Press, Lawrence, Kansas, 117-126.
- HARRINGTON, H. J. *et al.*, 1959. Systematic descriptions. In *Treatise on Invertebrate Palaeontology, Part O, Arthropoda 1*, R. C. Moore, ed., Geol. Soc. Amer. & Univ. Kansas Press, Lawrence, Kansas, 170-540.
- HENDERSON, R. A., 1983. Early Ordovician faunas from the Mount Windsor Subprovince, northeastern Queensland. *Mem. Ass. Australas. Palaeontols* 1: 145-175.
- HINIZE, L. J., 1953. Lower Ordovician trilobites from western Utah and eastern Nevada. *Bull. Utah geol. Miner. Surv.* 48: 1-249.
- HUPE, P., 1953. Classification des trilobites. *Annales Paleontologie* 39: 61-198.
- HUPE, P., 1955. Classification des trilobites. *Annales Paleontologie* 41: 91-325.
- JELL, P. A., 1981. Trends and problems in Cambrian trilobite evolution. *United States Geological Survey Open-File Report* 81-743: 97.
- JOHNSTON, R. M., 1888. *Systematic account of the geology of Tasmania*. Government Printer, Hobart.
- KOBAYASHI, T., 1934. The Cambro-Ordovician formations and faunas of south Chosen. *Palaeontology, Part 1. Middle Ordovician faunas. J. Fac. Sci. Tokyo Univ. ser. 2*, 3: 329-519.
- KOBAYASHI, T., 1936. Three contributions to the Cambro-Ordovician faunas. *Jap. J. Geol. Geog.* 13: 163-184.
- KOBAYASHI, T., 1940. Lower Ordovician fossils from Caroline Creek near Latrobe, Mersey River District, Tasmania. *Pap. Proc. R. Soc. Tasman.* 1939: 67-76.
- KOBAYASHI, T., 1955. The Ordovician fossils of the McKay Group in British Columbia, western Canada, with a note on the early Ordovician palaeogeography. *J. Fac. Sci. Tokyo Univ., ser. 2*, 9: 355-493.
- LANE, P. D. & THOMAS, A. T., 1983. A review of the trilobite suborder Scutelluina. *Spec. Pap. Palaeont.* 30: 141-160.
- LEGG, D. P., 1976. Ordovician trilobites and graptolites from the Canning Basin, Western Australia. *Geol. et Palaeont.* 10: 1-58.
- LEGG, D. P., 1978. Ordovician biostratigraphy of the Canning Basin, Western Australia. *Alcheringa* 2: 321-334.
- LUDVIGSEN, R., 1982. Upper Cambrian and Lower Ordovician trilobite biostratigraphy of the Rabbitkettle Formation, western District of Mackenzie. *Contr. Life Sci. R. Ontario Mus.* 134: 1-188.
- LUDVIGSEN, R. & CHATERTON, B. D. E., 1980. The ontogeny of *Failluana* and the origin of the Bumastinae (Trilobita). *Geol. Mag.* 117: 471-478.
- MAREK, L., 1952. Contributions to the stratigraphy and fauna of the uppermost part of the Kraluv Dvur Shales. (Ashgillian.) *Sb. Ustred. Ust. Geol.* 19: 429-455.
- PRANIL, F. & PRIBYL, A., 1949. On the genus *Symphysurus* Goldfuss and allied forms from the Ordovician of Bohemia (Trilobitae). *Mem. Soc. r. Sci. Boheme* 12: 1-16.
- RAYMOND, P. E., 1913. A revision of the species which have been referred to the genus *Bathyrurus*. *Bull. Victoria mem. Mus.* 1: 51-80.
- RAYMOND, P. E., 1925. Some trilobites of the Lower Middle Ordovician of eastern North America. *Bull. Mus. Comp. Zool.* 67: 1-180.
- ROSS, R. J., 1951. Stratigraphy of the Garden City Formation in northwestern Utah, and its trilobite faunas. *Bull. Peabody Mus. nat. Hist.* 6: 1-161.
- SHAW, A. B., 1951. Paleontology of northwestern Vermont, 1. New Late Cambrian trilobites. *J. Paleont.* 25: 97-114.
- SHERGOLD, J. H., 1975. Late Cambrian and Early Ordovician trilobites from the Burke River Structural Belt, western Queensland, Australia. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 153: 1-251.
- SKEFVINGTON, D., 1963. A correlation of Ordovician graptolite bearing sequences. *Geol. For. Stockh. Forh.* 85: 298-315.
- SHUTT, J. H., 1971. Cambrian-Ordovician trilobites western Arbuckle Mountains. *Bull. Okla. Geol. Surv.* 110: 1-83.
- WEBBY, B. D., VANDENBERG, A. H. M., COOPER, R. A., BANKS, M. R., BURRETT, C. F., HENDERSON, R. A., CLARKSON, P. D., HUGHES, J., LAURIE, J., SLAIT, B., THOMSON, M. R. A. & WEBBERS, G., 1981. Ordovician System in Australia, New Zealand and Antarctica. *IUGS Publ.* 6: 1-64.
- WHITTINGTON, H. B., 1963. Middle Ordovician trilobites from Lower Head, western Newfoundland. *Bull. Mus. Comp. Zool.* 129: 1-118.
- WHITTINGTON, H. B., 1965. Trilobites of the Ordovician Table Head Formation, western Newfoundland. *Bull. Mus. Comp. Zool. Harv.* 129: 1-118.

Explanation of Plates

PLATE 14

Etheridgaspis carolinensis (Etheridge, 1919)

- Figure 1. Latex cast of incomplete cranium showing large palpebral lobes and downturned posterior cephalic limb, NMVP74262, $\times 4$. (A) left anterior oblique view, (B) dorsal view.
- Figure 2. Latex cast of very small librigena showing short highly-arcuate eye, short genal spine and elevated posterior of the genal field, NMVP74263, $\times 4$. (A) dorsal view, (B) lateral oblique view.
- Figure 3. Internal mould of damaged librigena showing more elongate eye, Z1380A, $\times 3$. Figured by Etheridge (1883, pl. 1, fig. 3).
- Figure 4. Internal mould of librigena showing forward extension of the doublure, ornament, border furrow shallowing near genal angle, forward sloping genal field, and strong furrow beneath eye, NMVP74264, $\times 2.5$.
- Figure 5. Latex cast of smallest librigena available showing short arcuate eye, posteriorly shallowing border furrow, terrace lines on border and strong genal spine, NMVP74265, $\times 6$.
- Figure 6. Internal mould of damaged cranium, NMVP74266, $\times 4$.
- Figure 7. Internal mould of damaged cranium, NMVP74267, $\times 4$.
- Figure 8. Internal mould of damaged cranium, Z144, $\times 3$. Figured by Kobayashi (1940, pl. 12, fig. 10).

- Figure 9. Latex cast of librigena showing large eye, prominent subocular ridge, and posteriorly situated short genal spine, NMVP74276, $\times 6$.
- Figure 10. Latex cast from incomplete external mould of librigena with most anteriorly placed genal spine of all available specimens, NMVP74277, $\times 6$.
- Figure 11. Latex cast of librigena, NMVP74278, $\times 5$. (A) dorsal view, (B) lateral oblique view.
- Figure 12. Latex cast of large cranium showing glabellar furrows, terrace lines on anterior border, wide palpebral lobe and apparently distorted by shortening in sagittal direction, NMVP74270, $\times 5$. (A) anterior oblique view, (B) dorsal view.
- Figure 13. Internal mould of poorly preserved pygidium, NMVP74271, $\times 6$.
- Figure 14. Latex cast from incomplete external mould of small pygidium, NMVP74272, $\times 4$.
- Figure 15. Latex cast of pygidium showing pleural and interpleural furrows, narrow border and axial structure, NMVP74273, $\times 4$.

PLATE 15

Carolinites tasmaniensis (Etheridge, 1919)

- Figure 1. Latex cast from incomplete external mould of cranium in lateral oblique view, NMVP74274, $\times 5$.
- Figure 2. Latex cast from incomplete external mould of cranium showing baccula, AMF65504, $\times 6$. (A) lateral view, (B) dorsal view.
- Figure 3. Internal mould of cranium, Z1380B, $\times 4$. (A) dorsal view, (B) anterolateral oblique view. Figured by Etheridge (1883, pl. 1, fig. 12).
- Figure 4. Latex cast from incomplete external mould of cranium, AMF65505, $\times 7$.
- Figure 5. Latex cast from incomplete external mould of cranium Z142, $\times 6$. Figured by Kobayashi (1940, pl. 12, fig. 9).
- Figure 6. Latex cast from incomplete external mould of cranium showing ridge on inner edge of palpebral furrow, glabellar shape and lack of glabellar furrows, NMVP74275, $\times 6$. (A) dorsal view, (B) anterolateral oblique view.
- Figure 7. Internal mould of damaged holotype cranium, Z1387, $\times 5$. (A) dorsal view, (B) anterior oblique view.
- Figure 8. Latex cast of damaged cranium, AMF65506, $\times 5$.
- Figure 9. Internal mould of damaged cranium, NMVP74268, $\times 4$.

- Figure 10. Latex cast from incomplete external mould of cranium showing glabellar furrows and large palpebral lobe, NMVP74269, $\times 2.5$. (A) dorsal view, (B) anterior oblique view.
- Figure 11. Latex cast of small cranium, AMF65503, $\times 6$.
- Figure 12. Internal mould of small librigena, NMVP74279, $\times 3.5$.
- Figure 13. Internal mould of librigena, AMF65507, $\times 7$. (A) lateral view, (B) dorsal view.
- Figure 14. Latex cast from incomplete external mould of cranium showing well-impressed border furrow, NMVP74280, $\times 6$.
- Figure 15. Latex cast from incomplete external mould of pygidium, NMVP74281, $\times 7$.
- Figure 16. Latex cast of poorly preserved pygidium showing narrow pleural areas, AMF65508, $\times 9$.
- Figure 17. Latex cast from incomplete external mould of pygidium showing axial structure, narrow pleural areas, and well-impressed border furrow, NMVP74282, $\times 6$. (A) dorsal view, (B) posterolateral oblique view.

PLATE 16

Tasmanocephalus stephensi (Etheridge, 1883)

- Figure 1. Internal mould of medium sized cranium, NMVP74283, $\times 2$. (A) dorsal view, (B) anterior oblique view.
- Figure 2. Latex cast of hypostome showing terrace lines, wide shoulder, median furrow, and medially tapering posterior border, AMF65509, $\times 5$.
- Figure 3. Latex cast of hypostome, Z134, $\times 3$. (A) dorsal view, (B) left lateral oblique view. Figured by Kobayashi (1940, pl. 12, fig. 18).
- Figure 4. Latex cast of hypostome, AMF65510, $\times 5$.
- Figure 5. Latex cast of librigena in lateral oblique view, NMVP74284, $\times 3$.
- Figure 6. Latex cast from incomplete external mould of librigena showing border furrow, eye socle, and broad genal spine, NMVP74285, $\times 3.5$. (A) lateral oblique view, (B) lateral view.
- Figure 7. Latex cast of cranium showing narrow posterior cephalic limb, elevated short palpebral lobe, and anterior marginal terrace lines, Z148, $\times 3$. (A) anterior oblique view, (B) dorsal view.
- Figure 8. Latex cast from incomplete external mould of cranium showing glabellar furrows, eye ridge, caeca in front of eye ridge, and palpebral lobe, NMVP74286, $\times 3$.

Figure 9. Latex cast of incomplete cranium, NMVP74287, $\times 4$.

Figure 10. Latex cast of small incomplete cranium, NMVP74288, $\times 2$.

Figure 11. Latex cast of incomplete cranium showing glabellar furrows, NMVP74289, $\times 3$.

Figure 12. Internal mould of damaged cranium, Z1378, $\times 3$. Figured by Etheridge (1883, pl. 1, fig. 1).

Figure 13. Latex cast from incomplete external mould of large laterally compressed pygidium, NMVP74290, $\times 3$.

Figure 14. Latex cast of slightly distorted pygidium, NMVP74291, $\times 2.5$.

PLATE 17

Parabasilicus ? lewisi (Kobayashi, 1940)

Figure 1. Internal mould of laterally compressed cranium showing occipital and posterior border furrows and anteriorly expanding glabella, NMVP74292, $\times 5$.

Figure 2. Internal mould of damaged cranium showing outline of glabella, palpebral lobes, and course of facial suture, Z133, $\times 2$. (A) dorsal view, (B) anterolateral oblique view. Figured by Kobayashi (1940, pl. 12, fig. 16).

Figure 3. Internal mould of incomplete cranium showing palpebral lobe and occipital furrow, NMVP74293, $\times 2$.

Figure 4. Latex cast of laterally compressed cranium, AMF65511, $\times 3.5$.

Figure 5. Internal mould of hypostome, NMVP74294, $\times 5$.

Figure 6. Latex cast of pygidium, NMVP74295, $\times 3$.

Figure 7. Latex cast of damaged hypostome showing second pair of shallower pits behind the median furrow, NMVP74296, $\times 4$.

Figure 8. Latex cast of pygidium, NMVP74297, $\times 1.5$.

Figure 9. Latex cast of ventral surface of librigena showing posteriorly tapering doublure and anterior sutural margin of doublure, NMVP74298, $\times 2.5$.

Figure 10. Internal mould of damaged pygidium showing concave border, inner margin of doublure and space between doublure and dorsal exoskeleton, NMVP74299, $\times 2$.

PLATE 18

Figs 1-7 *Protoencrinurella ? subquadrata* (Kobayashi, 1940)

Figure 1. Internal mould of cranium showing short genal spine, NMVP74300, $\times 8$.

Figure 2. Latex cast of cranium, NMVP74301, $\times 8$.

Figure 3. Latex cast of glabella showing glabellar furrows with change of direction of 3p, NMVP74302, $\times 6$.

Figure 4. Latex cast from incomplete external mould of cranium, NMVP74303, $\times 6$.

Figure 5. Latex cast from incomplete external mould of pygidium showing abaxially elongate pleural ribs, NMVP74304, $\times 7$.

Figure 6. Internal mould of pygidium, NMVP74305, $\times 8$.

Figure 7. Latex cast of two incomplete pygidia, NMVP74306 and 74307, $\times 8$.

Figs 8-12 *Tasmanocephalus stephensi* (Etheridge, 1883)

Figure 8. Latex cast from external mould of fragment of left anterolateral corner of pygidium showing terrace lines, NMVP74308, $\times 3$.

Figure 9. Latex cast from incomplete external mould of pygidium showing axial and pleural structure, NMVP74309, $\times 3$.

Figure 10. Internal mould of pygidium, Z1381, $\times 3$. Figured by Etheridge (1883, pl. 1, fig. 4).

Figure 11. Latex cast of small pygidium, NMVP74310, $\times 3$.

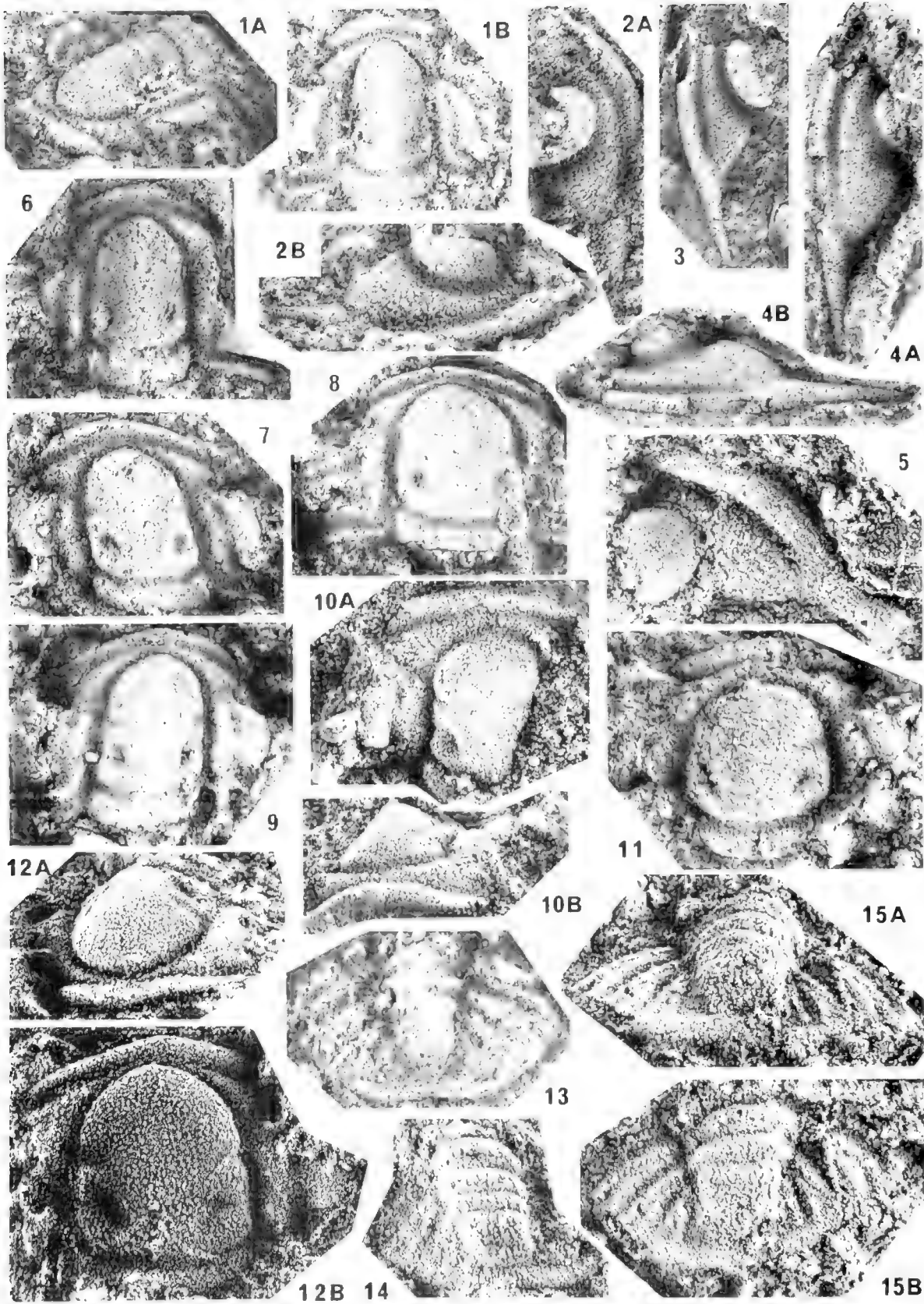
Figure 12. Latex cast from damaged external mould of slightly distorted pygidium, Z1380C, $\times 3$. (A) dorsal view, (B) right lateral oblique view.

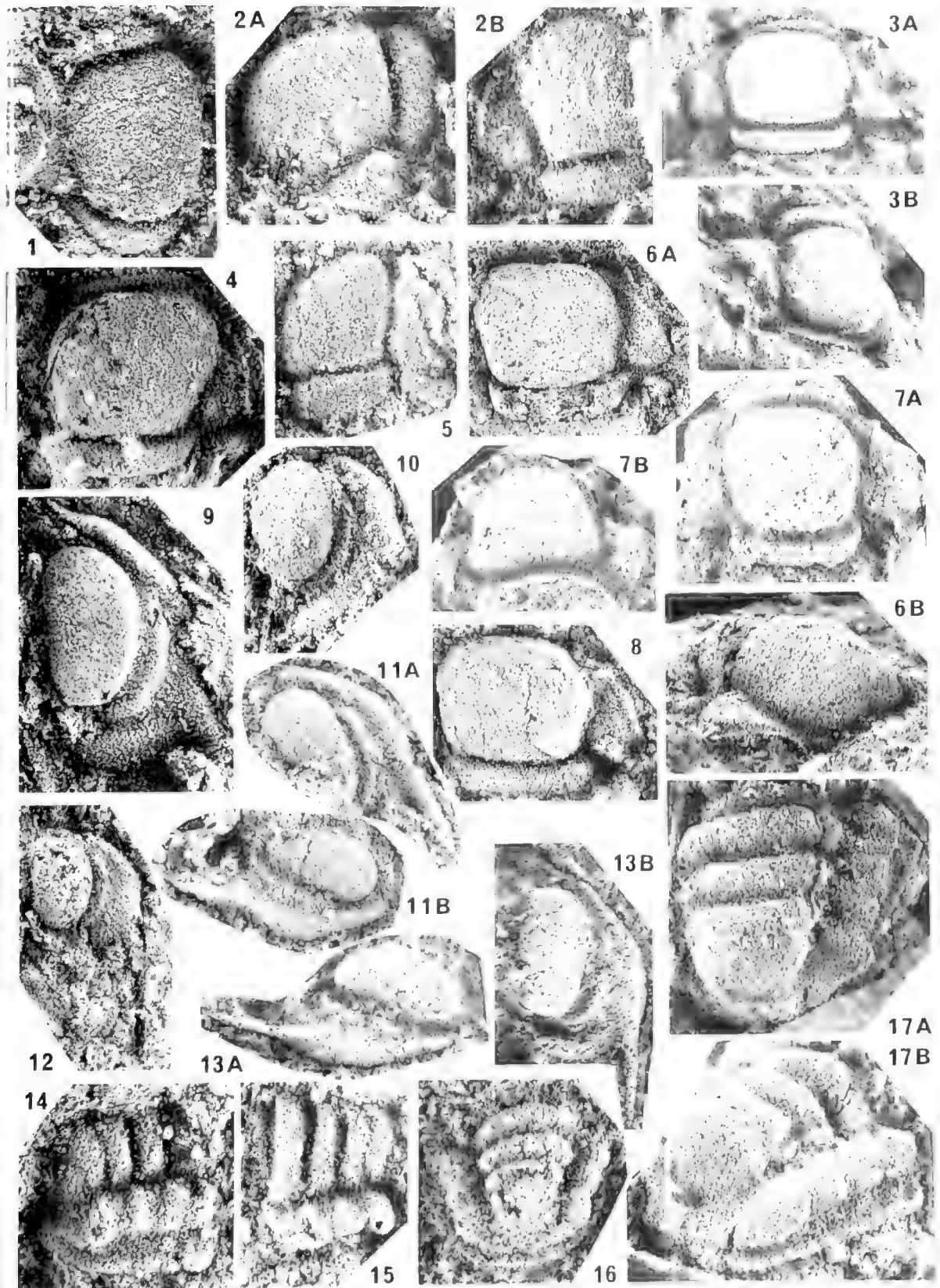
Figs 13, 14. *Parabasilicus ? lewisi* (Kobayashi, 1940)

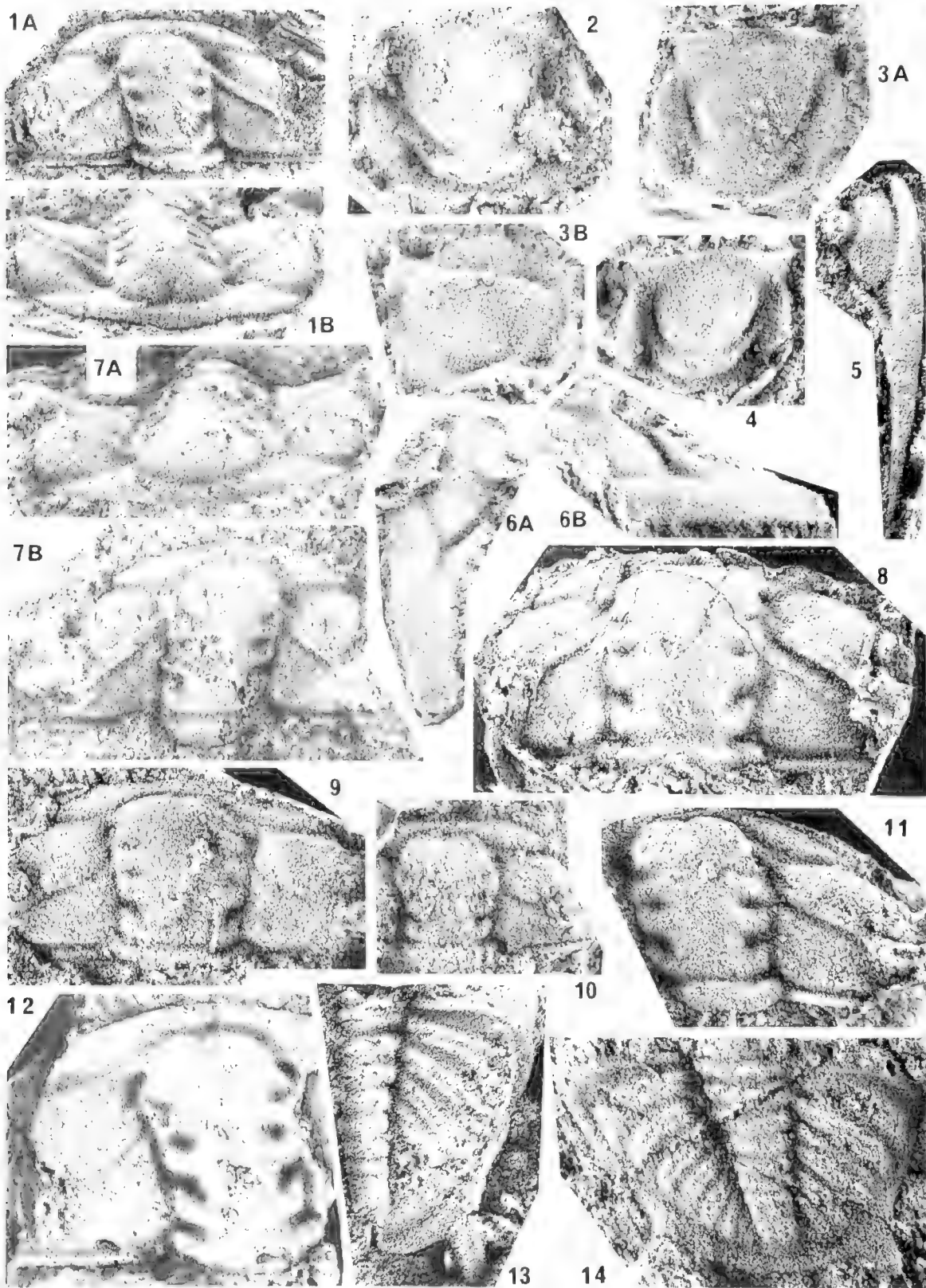
Figure 13. Internal mould of librigena showing lack of genal spine, course of facial suture, and terrace lines on doublure anteriorly, NMVP74311, $\times 2.5$.

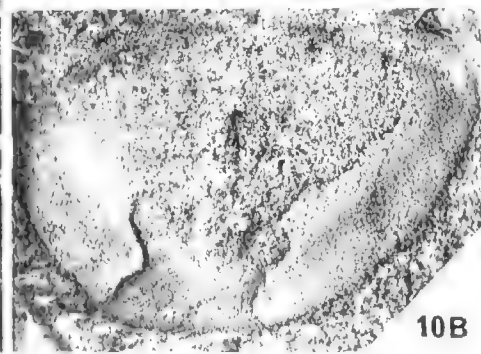
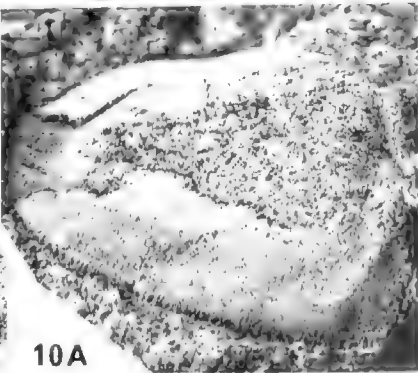
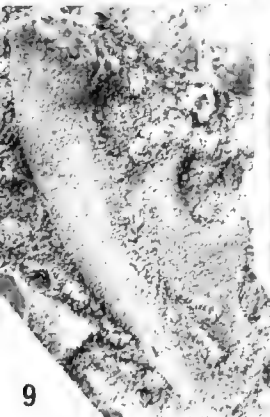
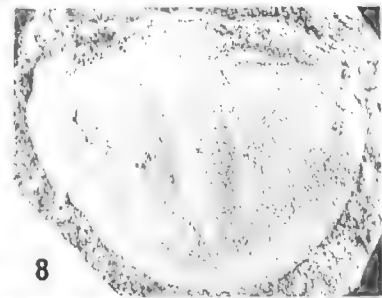
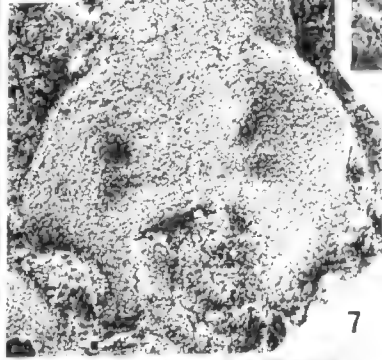
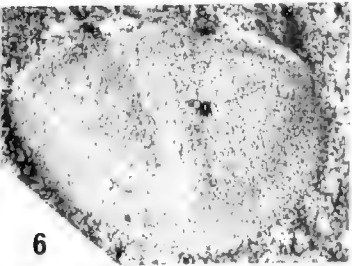
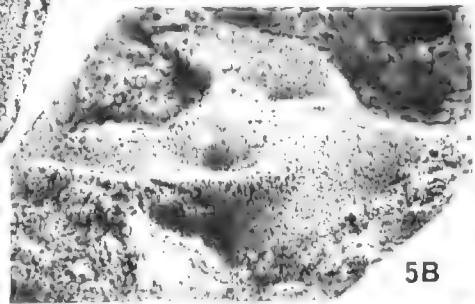
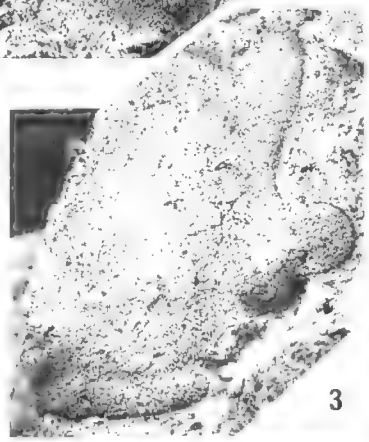
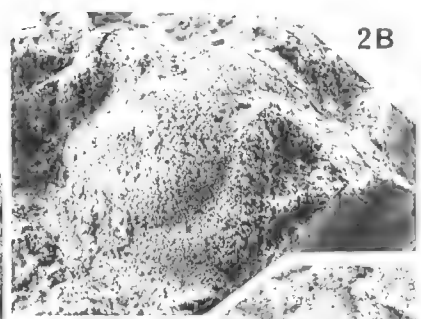
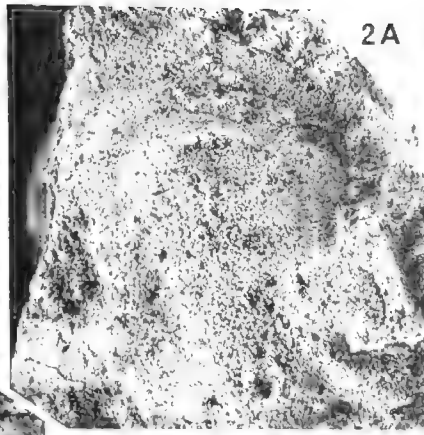
Figure 14. Internal mould of damaged librigena showing anterior extension of border in front of facial suture, NMVP74312, $\times 4$.

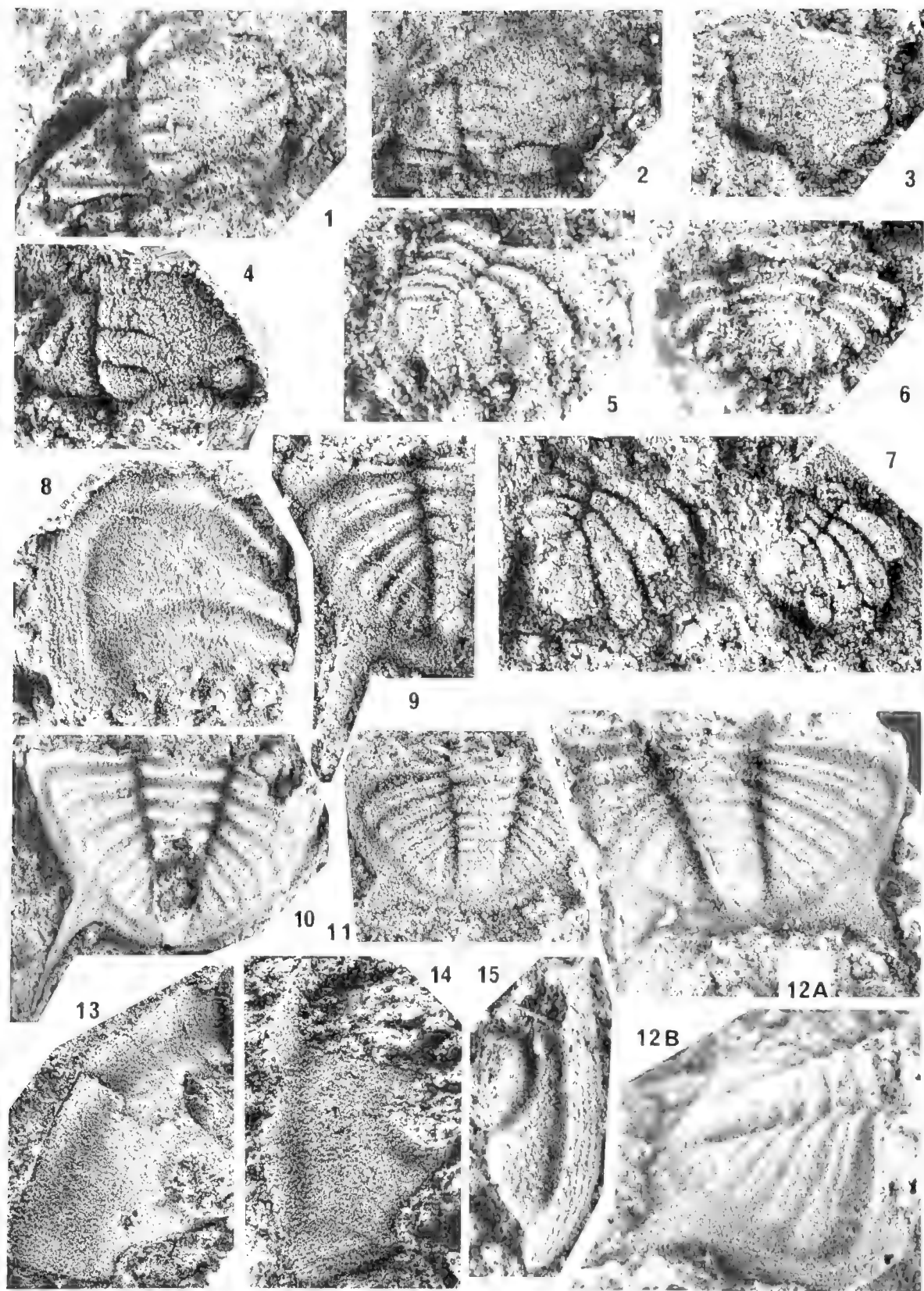
Figure 15. *Etheridgaspis carolinensis* (Etheridge, 1919). Latex cast of librigena, AMF65512, $\times 5$.











TREMADOC TRILOBITES OF THE DIGGER ISLAND FORMATION, WARATAH BAY, VICTORIA

BY P. A. JELL

Museum of Victoria, 285-321 Russell Street, Melbourne, Victoria 3000

Abstract

Trilobites of the Digger Island Formation at Digger Island, 1.5 km south of Walkerville on Waratah Bay, South Gippsland are described and assigned an early Tremadoc age approximately equivalent to the *Kainella meridionalis* zone of Argentina. It is impossible to correlate directly with any known Australian sequence but indirectly it is considered older than La 1.5 zone of the Victorian graptolite sequence and approximately contemporaneous with the *Oneotodus bicuspatatus-Drepanodus simplex* zone of western Queensland. Four new genera, *Natmus* (Hystricuridae), *Barachyhipposiderus* (Harpedidae), and *Landyia* and *Victorispina* (Pilekiidae) are erected with eleven new species, *N. victus*, *N. luberus*, *B. logimus*, *L. elizabethae*, *V. holmesorum*, *Neoagnostus eckardtii*, *Onychopyge parkerae*, *Pseudokainella diggerensis*, *Australoharpes singletoni*, *A. expansus*, and *Protopliomerops lindneri*. New taxa left in open nomenclature are referred to *Pilekia*, *Tessalacauda*, and the Hystricuridae. The Argentinian species *Micragnostus hoekei* (Kobayashi, 1939), *Shumardia erquensis* Kobayashi, 1937, and *Leioptegium douglasi* Harrington, 1937 are identified.

Introduction

Digger Island is a small stack approximately 75 m in diameter, isolated from the mainland above half-tide, and situated approximately 1.5 km south of Walkerville on the western shore of Waratah Bay, South Gippsland; it consists of brown, largely decalcified mudstones containing a rich faunule of trilobites, brachiopods, gastropods, hyolithids, and isolated cystoid plates. The first detailed account of the geology of this coastline (Lindner, 1953), to which readers are referred for details of locality and geological setting, contained a list of trilobite identifications by O. P. Singleton with nine specific and two generic *nomina nuda*. He assigned the faunule an early Tremadoc age on the basis of identifications of *Leioptegium* and *Kainella*.

Singleton (1967) divided the formation informally into three parts; 1, a lower portion of massive recrystallised grey limestone without fossils except for a single nautiloid; 2, brown decalcified mudstone with the trilobites and associates; and 3, upper shales and muddy limestones with orthoid brachiopods. On this occasion he listed only six trilobites at generic level and reiterated the Tremadoc age of the beds.

Kennedy (1971) recorded *Cordylodus rotundatus*, *Onetodus* sp., and *Drepanodus* spp. from the formation and concurred with the Tremadoc age. These conodonts were derived

from samples taken some distance along strike from the trilobite locality; they come from near locality 2 of Lindner (1953, fig. 3) (D. J. Kennedy pers. comm.). Webby *et al.* (1981) using *Kainella* and *Leioptegium* made a direct correlation between the *Kainella-Leioptegium* zone (i.e. trilobite zone D of Ross (1951) and Hintze (1953) in North America) and the Digger Island Formation fauna; they also made an indirect correlation between this North American zone and the LA 1.5 zone of *Psigraptus* of Cooper and Stewart (1979). At the same time, however, they showed the Australian trilobite fauna of the pre-Lancefieldian Datsonian stage as Leioptegiid/Kainellid/Ceratopygid (*Onychopyge*) whereas the Warrendian (contemporary of the Lancefieldian), had only a Leioptegiid component mentioned. If the association of leioptegiid with kainellid is so important then the text and chart of Webby *et al.* (1981) seem incongruous.

Jones *et al.* (1971, p. 23) suggested a late Tremadoc to early Arenig age for the Digger Island Formation.

None of the attempts to date the trilobite faunule has been based on detailed taxonomic study as evidenced by the description herein of 18 separate taxa; all were collected in decalcified mudstone in the middle of the Digger Island Formation, on the northern and western sides of Digger Island below or just above high tide level (Fig. 1).

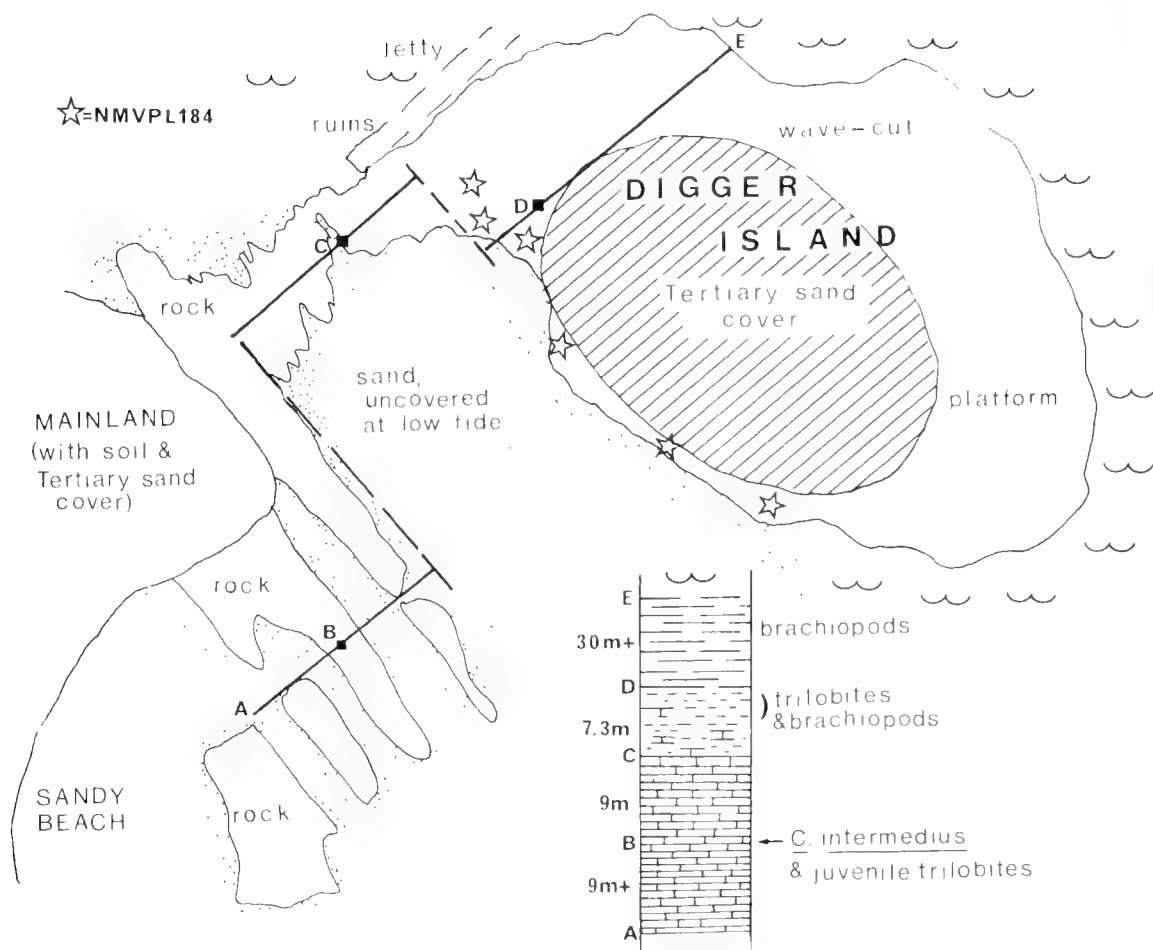


Figure 1. Sketch of Digger Island area showing position of section illustrated below as well as fossil collecting sites. Not drawn to scale and with north point approximately up page. C and D mark boundaries between members within the formation.

All illustrated material and other studied material are housed in the Palaeontological Collections of the Museum of Victoria (prefix NMVP) and the collecting site is designated NMVPL184 on the locality register of the same institution.

I am grateful for all the kindnesses listed below as well as any that I have inadvertently overlooked. Several people made collections for the Museum over a number of years, principally R. J. Paton, Eric Wilkinson, Peter Corcoran, Frank and Enid Holmes, Steve Eckardt, and John Talent. Other visitors, too numerous to mention have helped me to collect

on various occasions. Des Strusz, Bureau of Mineral Resources, loaned material for study from the BMR collections. Tom Bolton, Geological Survey of Canada provided photographs of *Pilekia apolla*. Richard Fortey, British Museum (Natural History), provided useful correspondence. Mr and Mrs Tony Landy of Walkerville South allowed access through their property and showed a keen interest in the project. Charlotte Parker assisted with sorting collections, some preparation and some photography. Penny Clark printed most of the photographs from my negatives. Annette Jell gave constant support especially on several col-

lecting trips and with curation of specimens. Heather Martin typed the manuscript.

Stratigraphy

A section (Fig. 1) was measured through part of the lower portion of the Digger Island Formation on the mainland opposite the southern side of Digger Island then offset along strike to measure the remainder of the Formation exposed along the northern side of the island. The description of lithology (Singleton, 1967) is verified but in view of the large component of mudstone and variety of lithologies, Lindner's (1953) original designation, Digger Island Formation, is retained.

Age

The trilobites of the Digger Island Formation described below are:

Micragnostus hoeki (Kobayashi, 1939)
Neoagnostus eckardti sp. nov.
Shumardia erquensis Kobayashi, 1937
Parahystricurus sp. cf. *P. fraudator* Ross, 1951
Hystricuridae gen. et sp. nov.
Natmus victus gen. et sp. nov.
Natmus tuberus gen. et sp. nov.
Leioestegium douglasi Harrington, 1937
Onychopyge parkerae sp. nov.
Pseudokainella diggerensis sp. nov.
Australoharpes singletoni sp. nov.
Australoharpes expansus sp. nov.
Brachyhipposiderus logimus gen. et sp. nov.
Landyia elizabethae gen. et sp. nov.
Victorisipina holmesorum gen. et sp. nov.
Pilekia sp.
Tessalacauda ? sp.
Protopliomerops lindneri sp. nov.

Correlation of this faunule on the basis of trilobites is much more difficult than previously thought and reference to the North American *Kainella-Leioestegium* zone cannot be considered certain; it does not contain *Kainella*, but rather *Pseudokainella* and *Leioestegium* is now known to be a longer ranging genus than previously thought (Chugaeva & Apollonov, 1982; Druce *et al.*, 1982).

Of species found elsewhere *P. fraudator* suggests late Tremadoc while *M. hoeki*, *S. erquensis* and *L. douglasi* occur together in the early Tremadoc zone of *Kainella meridionalis* in Argentina. *Onychopyge*, considered by

Robison and Pantoja-Alor (1968) to be indicative of earliest Tremadoc and also occurring in the *K. meridionalis* zone, occurs with *K. meridionalis* in New Zealand (Shergold *et al.*, 1982) although that identification is not yet substantiated by description or illustration. Four of the genera (*Leioestegium*, *Parahystricurus*, *Pilekia*, and *Tessalacauda*) occur in trilobite zone E (Ross, 1951; Hintze, 1953). *Pilekia* sp. is not unlike *Pilekia* sp. nov. from OT3 on the Gordon Road section (Jell & Stait, 1985) but none of the other 17 species from Digger Island even resemble any of the other species from the relatively close (geographically) Tasmanian fauna so a correlation would be difficult to accept.

In China Zhou and Zhang (1978) established an *Alloleioestegium-Onychopyge* Zone (*Alloleioestegium* = *Leioestegium*) based on a fauna containing *Onychopyge* similar to *O. parkerae*, a punctate species of *Leioestegium*, and a species of *Micragnostus* not unlike *M. hoeki*. This assemblage is the most likely to correlate with the Digger Island assemblage described below. The Chinese assemblage occurs within 15 m of *Dictyonema flabelliforme* in a section in Jilin Province (Chen *et al.*, 1983). However those authors considered that zone to correlate with the conodont zone immediately older than the one with which I correlate the Digger Island horizon. While their correlation may well be correct it does not take into account the occurrence of *Cordylodus intermedius* to the base of the *C. proavus* zone (Fortey *et al.*, 1982) nor does it acknowledge a range for *Onychopyge* as suggested by the Argentinian occurrences (Harrington & Leanza, 1957).

I consider that the Digger Island Formation trilobite fauna may best be correlated with the *Kainella meridionalis* zone of Argentina. They both contain the species *M. hoeki*, *S. erquensis*, and *L. douglasi* and have similar species of *Australoharpes*, *Pseudokainella*, and *Onychopyge* (Harrington & Leanza, 1957, pp. 16, 24, 246, 250). It should be noted that although *Onychopyge* is not tabulated by Harrington and Leanza (1957, table 1) as occurring in the *K. meridionalis* zone they (1957, p. 246) do list *Onychopyge* sp. in association with a *K. meridionalis* fauna from Rio Bocoya (upper Rio

Iruya) Santa Victoria Department of Salta Province (S. Vic-4). Further, the fauna from dark green and blue shales with dark blue marls and marly limestone in the Rio Volcancito section downstream from Puesto Nuevo (Harrington & Leanza, 1957, pp. 15, 16) on closer examination does not clearly belong to the *Parabolina argentina* zone. Of 22 species recorded nine occur at this locality only and a further eight have been found to range into the *K. meridionalis* zone already, so the older age is based on five species of which only two are widespread. It is possible that the range of these five species was greater than Harrington and Leanza (1957) thought. It should be noted also that Harrington & Leanza (1957, p. 250) recorded *Kainella* cf. *meridionalis* as coming from this locality which may indicate mixing of the two faunas in the collections from this 250 m of section. The association of *Dictyonema flabelliforme* with trilobites of the *K. meridionalis* zone suggests that this zone is older than the *Clonograptus*-*Psigraptus* zone (Cooper, 1979) and the basis for time equivalence of these zones (Ludvigsen, 1982a) is not clear although it is not impossible.

Assigning the Digger Island Formation trilobites to the *K. meridionalis* zone may explain the complete distinction between the Tasmanian and Victorian faunas—the latter is older, albeit only slightly older, than any Tasmanian Ordovician trilobite faunas so far described of which the oldest has been correlated with the *Psigraptus* zone (Jell & Stait, 1985). It would also suggest that the generic similarity with North American trilobite zone E refers to long ranging genera that migrated from Australia and Argentina to North America during the middle Tremadoc. I suggest that the species level correlation with Argentina is more significant than the generic level correlation with Utah even though it is based on fewer taxa at these levels. However, at the generic level the Argentinian correlation is based on more taxa.

The section (Fig. 1) shows that the level from which *Cordylodus intermedius* was extracted (K. Kenna, pers. comm.) was below the trilobite horizon and also, the horizon from which Kennedy (1971) extracted *C. rotundatus* was probably in the lower member, but some

300 to 400 m along strike, with no guarantee of continuity of the bedding (D. Kennedy, pers. comm., on site, August 1983).

Cordylodus intermedius ranges to the base of the *C. proavus* zone (Fortey *et al.*, 1982) so it is not useful for correlation in this case. The occurrence of *C. rotundatus*, if it is found to be in a continuous sequence with trilobites, suggests correlation with the zone of that name in the Black Mountain section of western Queensland and with North American conodont and trilobite zones B. The latter is compatible with Ludvigsen's (1982a, fig. 6) correlation of the *K. meridionalis* zone of Argentina also with North American zone B. However if the morphological similarities between *Leiostegium douglasi* from Victoria and *L. floodi* Shergold, 1975 from Queensland (see below) have any significance then the fauna could correlate with the *Oneotodus bicuspatatus*-*Drepanodus simplex* zone (Shergold, 1975). The cited occurrence of *L. floodi* in the *C. oklahomensis*-*C. lindstromi* zone (Druce *et al.*, 1982) is in error (J. H. Shergold, pers. comm. Nov. 1983). In fact direct correlation with any other Australian fauna is impossible at present.

Based on this information I assigned the Digger Island Formation fauna an early Tremadoc age, correlative with the *Kainella meridionalis* zone of Argentina and thereby probably contemporaneous with Lancefieldian 1 zone faunas of the Victorian graptolite sequence and possibly *O. bicuspatatus*-*D. simplex* zone faunas of western Queensland, i.e. it is older than suggested by Webby *et al.* (1981).

Preservation

The trilobites are preserved as moulds in very fine-grained decalcified mudstone but in many specimens a white mineral replacement has filled the void left after the exoskeleton; this mineral has come out of the mould with the latex cast in many instances (Pl. 19, figs 9, 10, 14; Pl. 20, fig. 12A, Pl. 27, fig. 1B).

The fossils have undergone considerable distortion after burial as evidenced by compression in all directions on different specimens. This, along with observations during collection, indicates that the fossils were not strictly in bedding planes but were oriented at any angle to

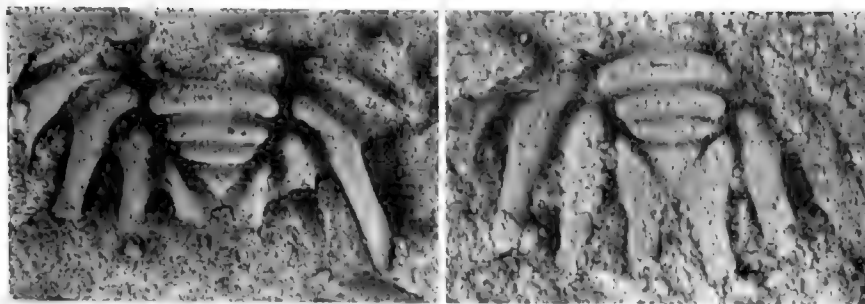


Figure 2. Pygidium (NMVP74460) of *Protopliomerops lindneri* illustrating the difference in appearance between internal mould (left) and latex cast from external mould (right).

the horizontal very often in small pockets of individuals lying on top of each other. Most of the individuals illustrated, came not from these agglomerations but rather from the less crowded areas where preservation was more complete. Distortion also took the form of fracture of exoskeletons in almost every species, certainly the larger ones. This fracturing affected some individuals but not others of the same species and flexibility of the exoskeleton is shown by some unfractured individuals (e.g. Pl. 27, fig. 1A). Long delicate spines are retained and many articulated specimens are preserved so the environment must have been quite tranquil. Presumably, therefore, the fracturing was immediately post-depositional before lithification and the distortion by compression could have been anytime during diagenesis. Large flat cranidia of *Australoharpes expansus* (Pl. 28, figs 2, 4B) show that a weak cleavage was just beginning to develop.

The pygidia of *Landyia elizabethae* (Pl. 30, fig. 8; Pl. 31, fig. 2) and of *Protopliomerops lindneri* (Fig. 2) show clearly the different morphologies of internal mould and external surface when the exoskeleton has some thickness; they warn against the use of internal moulds only, when describing decalcified specimens.

Systematic palaeontology

Terminology follows Harrington, Moore and Stubblefield (1959) as far as possible; all dimensions in the sagittal or exsagittal directions are discussed in terms of length and all dimensions in the transverse direction are discussed in terms of width (for example the anterior cranidial border whose sagittal dimension is

often important in specific description is described in terms of long or short in our terminology). Occipital ring is included in the glabella. The state of preservation of the fossils removes any confidence in the use of any biometrics so no measurements or reconstructions are included in the descriptions; sizes of individuals are indicated in explanations of the plates and most distinguishing characters are not measurements.

Class Trilobita

Family AGNOSTIDAE McCoy, 1849

Subfamily Agnostinae McCoy, 1849

Micragnostus Howell, 1935

Type species (by original designation): *Agnostus calvus* Lake, 1906.

Remarks: I follow Fortey (1980) in the concept of this genus with the transverse glabellar furrow well in front of the glabellar node being particularly distinctive.

Micragnostus hoeki (Kobayashi, 1939)

Plate 19, figures 6-14

1937 *Geragnostus tullbergi* Novak; Kobayashi, p. 464, pl. 2, figs 3-5.

1938 *Geragnostus tullbergi* Novak; Harrington, p. 160, pl. 4, fig. 2 (NOT fig. 1).

1939 *Geragnostus hoeki* Kobayashi, p. 169, 171.

1957 *Geragnostus* (*Micragnostus*) *hoeki* Kobayashi; Harrington & Leanza, p. 68, fig. 11-3, 4, 5, 6.

Material: Lectotype (designated Harrington & Leanza, 1957, p. 68), cranidium figured by Kobayashi (1937, pl. 2, fig. 3), paralectotypes cranidium and pygidium figured by Kobayashi (1937, pl. 2, figs 4, 5) from Bolivia. Some 40 to 50 internal and external moulds from NMVPL

184 including NMVP74324 to 74332 are assigned to this species.

Description: Cephalon with inverted U-shaped margin forward of genal angles, moderately convex; glabella tapering gently forward, to rounded or subacuminate anterior, convex and raised above cheeks, 0.7 of cephalic length and 0.4 of width, with well-impressed transverse transglabellar furrow isolating anterior glabella lobe 0.3 of total glabellar length, with prominent median node situated well behind transglabellar furrow, with two pairs of rounded muscle scars evident on posterior lobe of internal moulds with more posterior pair at level of node; axial furrow extending a little forward as the basal part only of a median preglabellar furrow; basal lobes small, triangular; cheeks smooth or with faint radial furrows (scrobiculations) on anterolateral parts of internal moulds; border furrow long and shallow anteriorly, virtually only a change in slope; border tapering and twisting to become steeper posteriorly, virtually a flange around the cheeks with very little convexity.

Pygidium U-shaped in outline, strongly convex, wider than long; axis parallel-sided, flaring slightly anteriorly adjacent to first segment, rounded posteriorly, occupying 0.6 of length and 0.7 of width of pygidium; anterior segment consisting of pair of subtrapezoidal lobes isolated by first transaxial furrow swinging forward to articulating furrow (not connected across axis at all); second segment longer than first, with short wide teardrop-shaped median tubercle encroaching slightly over terminus with small median pointed extension; second transaxial furrow transverse, continuous, very poorly impressed to obsolete; axial furrow poorly impressed but becoming less distinct posteriorly around terminus especially on external surface; border furrow defined by marked change of slope only; border and border furrow forming wide flange that tapers anteriorly and slopes gently laterally, with pair of small marginal spines situated just forward of the level of the posterior of the pleural areas, with border of considerable length and uniform between spines.

Remarks: Although Kobayashi's (1937) illustra-

tions and description are inadequate as noted by Harrington and Leanza (1957), the amplifying illustrations of the latter authors make identity of this species clear. There can be little doubt about the identity of the Victorian material as all features are in agreement when some allowance is made for the compression of the Argentinian specimens relative to the full relief of the Victorian ones. The articulated specimen (Pl. 19, fig. 7) is illustrated only to show the association of head and tail; its surface is badly abraded even by applying colloidal graphite for photography.

This species may be distinguished within the genus by the combination of wide border, axis occupying relatively small part of pygidium, course of first transaxial furrow on pygidium and development of posterior part of median preglabellar furrow. Features outlined by Fortey (1980) as characteristic of this genus are all readily apparent, in particular the position of the glabellar node and transglabellar furrow.

Family DIPLAGNOSTIDAE Whitehouse, 1936

Subfamily PSEUDAGNOSTINAE
Whitehouse, 1936

Neoagnostus Kobayashi, 1955

Type species (by original designation):
Neoagnostus aspidooides Kobayashi, 1955.

Neoagnostus eckardti sp. nov.
Plate 19, figures 1-5

Etymology: This species is named for Mr Steve Eckardt who donated material towards this study.

Material: Holotype NMVP74323, paratypes NMVP74319 to 74322, all from NMVPL184.

Diagnosis: Members of *Neoagnostus* with wide border furrow and border, with median preglabellar furrow, with chevron-shaped median lateral furrows on posterior glabellar lobe, with glabellar node in angle of the chevron, with rounded glabellar anterior. Pygidium with elongate bulbous but not bifid axial node on second segment, with almost circular areas in the third axial ring just posterolateral to glabellar node well-defined by discontinuous transaxial furrows, with prominent median node just for-

ward of border furrow, with short marginal spines at a level as far forward of the posterior median node as the length of the posterior border.

Description: Cephalon with evenly curved margin, widest at level of anterior glabellar lobe; glabella occupying 0.75 of cranial length, anteriorly rounded, with anterior and posterior glabellar furrows joined by short sagittal furrow isolating two large lobes giving spectaculate appearance in sense of Shergold (1977); anterior transglabellar furrow in waveform, with anterior crests laterally and angular posterior crest medially; posterior transglabellar furrow ('median lateral furrow of posterior glabellar lobe' of Shergold, 1975) chevron shaped, well-impressed throughout; prominent glabellar node in angle of chevron; posterior half of glabella rounded (in sense of Opik, 1967), with small posteromedian node barely evident (clearly evident upon examination with microscope); basal glabellar lobes triangular, joined behind glabella; preglabellar median furrow shallow but distinct, continuing to border furrow; cheeks smooth; border furrow wide, shallow, tapering posteriorly; border only a narrow marginal rim barely raised but convex, also tapering posteriorly to almost nothing at genal angle; posterior border furrow sharp, at angle to transverse, dividing off subtriangular posterior border.

Pygidium subquadrate to subovoid, strongly convex; internal mould showing distinct axial furrows converging posteriorly but reaching only as far as rear of the axial node, with division between first and second axial rings (in front of node) not evident, with prominent teardrop-shaped undivided median node on second ring, with transaxial furrow at rear of node transverse laterally then curving back behind node near axis, with subcircular lobes (probably muscle attachment scars) anterolaterally on third ring outlined by distinct furrows; anterior margin of first axial ring convex forward laterally, arched back medially; prominent medial node just above posterior border furrow; border furrow shallow, of uniform width; border wide, not markedly differentiated from border furrow, tapering

forward over anterior half of pygidium, with faint epiborder furrow (Pl. 19, fig. 1A) posteriorly between the spines ('zonate' in the terminology of Opik, 1967), with pair of short marginal spines situated well in front of the posteromedian node just in front of border furrow.

Remarks: Morphological features described place this species in the *bilobus* Group of *Neoagnostus* as defined by Shergold (1977). The only feature that needs emendation in the light of this new species and which distinguishes the species from others is the reference to the level of the pygidial marginal spines; whereas in all species noted by Shergold (1977, p. 79) these spines are level with the rear of the pleural areas or behind it, *N. eckardti* has the marginal spines the length of the posterior border in front of that transverse line. The epiborder furrow posteriorly on the pygidium (Pl. 19, fig. 1A) is also unique within the Group. *Pseudagnostus quasibilobus* Shergold, 1975 may be distinguished by its less distinct glabellar furrows, more angular glabellar rear, lack of third pair of muscle scars on pygidial axis (on exfoliated specimens) and by the posterior position of the pygidial marginal spines. Other Australian species of *Neoagnostus* have been assigned to different species groups of the genus and the diagnoses of the species groups. (Shergold, 1977) distinguish each of them from *N. eckardti*, making direct comparisons unnecessary.

Movement forward of pygidial marginal spines between Late Cambrian species of the Group and *N. eckardti* might appear to be the lineage that was suggested to exist by Fortey (1980) leading to *Arthrorhachis* and/or the rest of the Metagnostinae in which the forward position of the spines is normal. However, the fact that the first transaxial furrow in *Arthrorhachis* is well impressed and the third pygidial axial ring is undivided suggest that the Metagnostinae arose by another lineage and that the migration of the marginal spines was a phenomenon of each. It is however, further support for Fortey's (1980) contention that they need to be included within the same higher taxon.

Family SHUMARDIIDAE Lake, 1907

Shumardia Billings, 1865

Type species (by original designation):
Shumardia granulosa Billings, 1865.

Shumardia erquensis Kobayashi, 1937

Plate 19, figures 15-19

Material: The specimen figured by Kobayashi (1937, pl. 6, fig. 1) is herein designated lectotype and the other cranidium and pygidium figured by Kobayashi (1937, pl. 6, figs 2, 3) become paralectotypes. Five cranidia NMVP 74333 to 74337 are known from NMVPL184.

Remarks: Kobayashi's (1937, p. 483) description reiterated by Harrington and Leanza (1957, p. 79) is adequate for the material in hand. The slightly expanded frontal glabellar lobe, two pairs of lateral glabellar furrows, preglabellar field of identical length, well-impressed occipital and posterior border furrows, fine border and broadly rounded glabellar anterior are all evident on one or other specimen. It should be noted that the preglabellar field in the Argentinian material appears longer than in the Victorian because of compression in the former but the full length, mostly in an almost vertical slope, in the latter is apparent in anterior view (Pl. 19, fig. 19A). The close similarity and possible synonymy with the Swedish species *S. bottnica* Wiman, 1905 as discussed by Harrington and Leanza (1957) needs further investigation as the apparent absence of glabellar furrows on the Swedish species may simply be due to lack of detail in the wash drawing or to poor preservation. In the Victorian material the degree of expansion of the frontal glabellar lobe is variable so that at least one specimen has a parallel-sided glabella with virtually no expansion. Taking this degree of variability into account it appears almost impossible to generically separate *S. erquensis* from *Eoshumardia cylindrica* Shergold, 1971 in which the faint lateral glabellar furrows are illustrated (Shergold, 1975, pl. 58, figs 2, 3). However, *S. erquensis* could not be assigned to *Koldinioidia* Kobayashi, 1931 in the light of Shergold's (1975) emended diagnosis of that genus.

Family HYSTRICURIDAE Hupe, 1953

Parahystricurus Ross, 1951

Type species (by original designation):
Parahystricurus fraudator Ross, 1951, from Zone 'F' of the Garden City Formation in northeastern Utah.

Parahystricurus sp. cf. **P. fraudator** Ross, 1951

Plate 20, figures 1-3

Material: Four (three internal moulds and one external mould) damaged cranidia including NMVP74338 to 74340 in various states of completeness from NMVPL184.

Remarks: These cranidia provide an incomplete understanding of the Victorian population. However, there are few points of disagreement with material figured by Ross (1951). The preglabellar field is apparently a little longer in the Utah population but appears to be variable in the Victorian population and this may not be a distinctive feature. The 1p lateral glabellar furrow appears to be more deeply impressed in the internal moulds from Victoria than on the external surfaces from Utah; this difference appears to be more than mere surficial differentiation but is not considered to be specifically distinct. Glabellar sides taper more noticeably in the Victorian than American material. Of particular note are the short laterally bulging palpebral lobes and their position at the level of the 2p glabellar furrow; this feature and the resultant long triangular posterior cephalic limb are the main features used to separate the genus from *Hystricurus* Raymond, 1913.

Hystricuridae gen. et sp. nov.

Plate 20, figures 4-8

Material: Eleven incomplete, generally poorly preserved cranidia from NMVPL184 including NMVP74341 to 74345.

Description: Smooth cranidium with convex glabella standing above cheeks; glabella tapering forward with convex sides to rounded anterior, with poorly impressed shallow 1p glabellar furrow low on side of glabella and at high angle to transverse line; occipital furrow well impressed, curving forward near extremity, and distinct apodemal pits laterally also angling forward abaxially, extremely shallow

beyond apodeme; occipital ring short, convex, tapering laterally as it curves forward with furrow, running across axial furrow as marked ridge into posterolateral corner of fixed cheek; axial furrow well-impressed (shallower in front of glabella) deep, with prominent fossular pits at anterolateral corners of glabella, running into occipital furrow posteriorly seemingly without reaching posterior border; cheeks narrow, horizontal in anterior profile but sloping anteriorly in lateral profile; palpebral lobe of moderate length, situated opposite midlength of glabella, only gently convex and slightly upturned laterally, without palpebral furrow; preglabellar field short, convex; anterior border furrow poorly impressed but distinct, almost transverse on cranium; anterior border as long medially as preglabellar field, gently convex, gently arched in anterior profile, tapering strongly laterally along facial suture; facial suture convex out and converging slightly anteriorly from palpebral lobe, turning sharply adaxially from border furrow to run diagonally across border apparently reaching margin at or near midline, running just behind transversely for short distance behind palpebral lobe before curving back to run to the margin diagonally.

Remarks: Rather standard features, inadequate material and poor preservation make assignment of this species impossible. Although it is probably the species referred to by Singleton (in Lindner, 1953) and by Beavis (1976) as *Onchonotus* Raymond, 1924 it may not be assigned to that genus as the fixed cheeks do not slope laterally, there is a distinct preglabellar field, fossulae are distinct, the glabella is not so convex, and the palpebral lobe is longer, less convex, and situated further forward. It is not unlike *Onchopeltis* Rasnitsin, 1944 but may be distinguished by its ornament, and the course of the facial suture across the anterior border. *Onchonotina* Lu 1964 (see Lu *et al.*, 1965, pl. 38, fig. 7) has no preglabellar field or fossulae. It is not unlike *Pseudotalbotina* Benedetto, 1977 but may be distinguished by the course of the facial suture across the anterior border. Most of the features of this species are evident in one or more species of hystricurid described by Ross (1951) but the combination is not

achieved in any of them. I prefer to acknowledge this species as representative of an undescribed genus within the Hystricuridae that must await discovery of better material for formal definition.

Natmus gen. nov.

Etymology: The genus and species names are for the National Museum of Victoria which became the Museum of Victoria in July 1983 and within which this work was begun.

Type species: *Natmus victus* sp. nov.

Diagnosis: Glabella long, with two pairs of lateral furrows low on steep slope into axial furrow, with broadly rounded anterior, with short horizontal occipital spine; anterior border strongly upturned and very short; anterior border furrow with row of pits; palpebral lobes extremely short, situated posteriorly level with glabellar lobe 1p, markedly elevated although flat on top and higher than glabella, with eye ridge running to axial furrow at level of furrow 2p. Librigena with very long genal spine and border furrow discontinuous around genal angle. Thorax of more than 16 segments, with median node on each axial ring, with well-impressed pleural furrow running in midlength and with steep wide articulating facets.

Remarks: The affinities of this genus are entirely obscure with a resemblance to *Psalikilus* Ross, 1951 the only clue. Like *Psalikilus* it has no preglabellar field, two pairs of well-impressed lateral glabellar furrows, a long genal spine and short arcuate palpebral lobes situated posteriorly. However, the two are distinguished by the ornament, level at which the eye ridge meets the axial furrow, and details of the position and size of the palpebral lobe. For the moment it is left with *Psalikilus* in the Hystricuridae, but further discoveries of related genera and better material of this genus may necessitate erection of a family to accommodate this lineage which seems separate from the several others that are thought to originate in the Hystricuridae.

Natmus victus sp. nov.

Plate 21, figures 1-15

Material: Holotype NMVP74352, paratypes NMVP74350, 74351, 74353 to 74364.

Diagnosis: Member of *Natmus* with anterior of glabella almost reaching border furrow, with preglabellar field either absent or up to length of anterior border if present.

Description: Glabella subquadrate (probably longer than wide) with broadly rounded anterior, strongly convex, with straight parallel sides and with two pairs of well-impressed lateral glabellar furrows; furrow 1p beginning in axial furrow, running posteroaxially at approximately 45 degrees to transverse line up steep side of glabella, narrow but relatively long, not reaching occipital furrow but close to it; furrow 2p narrower than 1p, low on side of glabella, longer than 1p, joining axial furrow, with deeper pit at adaxial end, transverse; lobes 1p and 2p of equal length but frontal lobe more than twice as long as either; occipital furrow long shallow and transverse medially, shorter with deep apodemal pit and curved forward abaxially; occipital ring only slightly longer than furrow, slightly shorter laterally, with short tapering spine rising from full length of ring axially then turning posteriorly with most of spine lying in horizontal plane, with ornament of fine terrace lines more or less parallel to posterior margin; axial furrow very deep, crossed by low ridges from occipital ring and lobe 1p into proximal part of fixigena, splitting anteriorly to run directly forward to the border furrow and also curve around the anterior of the glabella; anterior border extremely short, highly convex, transverse, with fine terrace lines parallel to the margin; anterior border furrow short, distinct mainly as a change of slope to the upturned border; fixigena rising up very steeply from axial furrow, flattening off abaxially, of uniform width in front of palpebral lobe where lateral rise is less steep and where it slopes anterolaterally to border furrow; eye ridge prominent, leaving axial furrow at level of furrow 2p, appearing to issue from posterolateral corner of glabellar lobe 3p, running up fixigena at about 30 degrees to transverse line to meet anterior of posteriorly placed palpebral lobe; palpebral lobe short, semielliptical and well rounded abaxially, in horizontal plane above highest point of glabella, gently convex in section and defined by distinct palpebral furrow parallel to the abaxial margin of

palpebral lobe, situated opposite glabellar lobe 1p; posterior cephalic limb wide, short, with convex in section and defined by distinct palpebral furrow parallel to the abaxial margin of uniform length to the facial suture; facial suture almost exsagittal forward of palpebral lobe but with slight convexity opposite frontal glabellar lobe then curving strongly across border so that border extends laterally only a short distance beyond axial furrow, transverse behind palpebral lobe for considerable distance then curving through 90 degrees and meeting posterior margin in short distance. Ornament on fixigena and glabella except for furrows eye ridge and broad zone around lateral glabellar furrows of coarse reticulate ridges, with that on glabella and behind eye ridge on fixigena being much finer ridges than anteriorly on fixigena, with that on glabella less reticulate and more like terrace lines. Librigena with strong, long, curving, advanced, genal spine deflected laterally for some distance; eye surface small, bulbous, standing vertically; eye socle very low, merely a convex rim beneath the eye, separated from genal field by high wide furrow without ornament; genal field sloping steeply to border furrow, with ornament of coarse reticulate ridge and punctate interspaces; border furrow well-impressed and narrow anteriorly, becoming wider and shallower posteriorly, virtually discontinuous around genal angle, with posterior border furrow extending laterally to near base of genal spine but with discrete termination; border narrow highly convex anteriorly, becoming wider and flatter posteriorly, with fine comarginal terrace lines extending down length of genal spine and onto border behind genal spine.

Thorax of more than 16 segments; axis of relatively low convexity, with deep distinct apodemal pits laterally in articulating furrow, with median node on each segment, tapering posteriorly especially in posterior part, with length of segments becoming progressively less posteriorly; pleural areas horizontal to articulating line then only gently downturned abaxially. Transverse near anterior but curving posteriorly just in front of pygidium; pleural furrow with steep anterior and gentle posterior walls, distinct, running diagonally from

anterior margin at axial furrow to midlength in articulating line, extending abaxially in midlength almost to pleural tip; articulating facet wide, extending from articulating line to tip, steeply sloping, gently concave; pleural tip pointed but not spinose.

Remarks: *Natmus victus* is distinguished from *N. tuberus* sp. nov., in that the latter species has a long preglabellar boss and a fixigenal spine. Assignment of the thorax is based on the damaged internal mould (Pl. 21, fig. 11) having precisely the same pleural morphology as the external mould of the thorax with only damaged cranidium attached.

Although superficially similar, the ornament on the glabella and on the cheeks may be different functionally. On the cheeks there appear to be two sets of ridges with a set of normal caeca running into the eye ridge or the base of the eye etc. and a second set more or less at right angles and parallel to the margin overlying the former (Pl. 21, fig. 12). However, those on the glabella do not have the same regularity and may well be terrace line ornament evolved to give a uniform appearance to the whole head. Such a uniformity could well have been selected for in the face of predation. These glabellar terraces are interpreted as identical with the second set of ridges mentioned on the cheeks; caeca are not developed on the glabella. It should be noted that on a number of internal cranidial moulds of *N. victus* and *N. tuberus*, the ridges are present on the cheeks but absent from the glabella (Pl. 20, fig. 12B; Pl. 21, fig. 11) indicating that those on the glabella were an external surface feature only, whereas those on the cheeks (or at least some of them) represent internal organs close against the exoskeleton.

***Natmus tuberus* sp. nov.**

Plate 20, figures 9-12

Etymology: From the Latin *tuber* meaning a swelling or lump and referring to the preglabellar boss.

Material: Holotype NMVP74349, paratypes NMVP74346 to 74348 from NMVPL184.

Diagnosis: Member of *Natmus* with prominent preglabellar boss and fixigenal spine at abaxial tip of posterior cephalic limb.

Remarks: As this species is known from damaged and incomplete material only, it is difficult to give a full description and moreover, the two characters used in the diagnosis are the only ones observed that vary from the description of *N. victus* given above. Since there is a range of variation in development of a preglabellar field in *N. victus* it is not difficult to imagine the transition from one form to the other. Although the librigena of this species is not positively identified it may be confidently assumed to be the same as or similar to that of *N. victus* and so, with the fixigenal spine this species would have two posteriorly directed spines in the genal region. One internal mould of *N. victus* exhibits the beginning of a fixigenal spine so that progression in this feature may also be available if enough well preserved specimens were to be found. It therefore seems likely that this is a dithyrial population with the two morphs being termed species in this case and some evidence of intermediate morphs but not an intergrading series. A larger sample of the population is needed to say more.

Although a preglabellar boss develops in a number of different trilobite groups and similar prominent ridged ornament is known in several of these other groups none of the other forms combines the small posteriorly situated palpebral lobes and pitted anterior border furrow. The close similarity with *N. victus* indicates a lineage separate from any of the other boss-bearing forms and direct comparison is superfluous.

Family LEIOSTEGIIDAE Bradley, 1925

***Leiostegium* Raymond, 1913**

***Leiostegium douglasi* Harrington, 1937**

Plate 22, figures 1-10

Material: Holotype No 4356 in the collection of the Department of Geology, University of Buenos Aires, Argentina; paratypes Nos 4354 and 4357 in the same collection; more than 100 cranidia, librigenae, hypostomes, thoracic segments and pygidia from NMVPL184 where it is one of the commonest species.

Description: Only alterations or additions to the already comprehensive description of Harrington (1937) and Harrington & Leanza (1957)

are provided. One exfoliated cranidium shows four pairs of lateral glabellar furrows that are not evident on the exterior of the exoskeleton. Furrow 1p is indistinct, relatively large, forked adaxially and occupies almost one-third of the glabella in front of the occipital furrow; furrow 2p is more distinct, situated near anterior of palpebral lobe, close to axial furrow, with transverse anterior fork and posteroaxially directed rear fork, as wide as long (length measured across adaxial tips of furrows); furrow 3p short, wide but narrowest of all furrows, situated well away from axial furrow close to 4p just in front of junction of eye ridge and axial furrow; 4p rising up side of glabella from axial furrow, transverse or directed a little forward. A strong ridge runs out of the anterolateral corners of the glabella across the axial furrow and into the anteroproximal corner of the fixigena; in front of this ridge is a deep pit (fossula) and behind it is another pit whose impression is greater on the external surface than the internal mould. On the internal moulds described from Argentina the pit behind the ridge is accordingly almost imperceptible but I suggest it would be present on the exterior of the exoskeleton of that material as it appears to be a familial character. The anterior border is relatively quite long by comparison with other species of the genus. The eye ridge is well developed but only evident on the internal mould; fine caeca run out of the eye ridge both anteriorly and posteriorly. Fine caeca may also be seen running forward from the anterior border furrow onto the posterior part of the anterior border (Pl. 22, fig. 1). In lateral profile the palpebral lobes are horizontal and elevated though not as high as the axial ridge of the glabella and there is a distinct anterior drop down to the much lower but also flat anterior border. On the surface of the internal mould are numerous pustules and/or circular depressions with small medial pustules representing pits or fine rimmed pits on the inner surface of the exoskeletons. These presumably correspond to the fine pits on the exterior surface seen in some specimens (e.g. Pl. 22, fig. 2) so that the exoskeleton is essentially perforate. The librigena has fine terrace lines on the doublure extending dorsally over the margin in some specimens.

Thorax of eight segments has very wide pleural areas that are flat to the articulating line then turn down only slightly. Pleural furrow is well-impressed and runs through midlength of each segment petering out just beyond articulating line. Pleura beyond articulating line extended as free spines curved slightly back with amount of curvature increasing posteriorly. The spine is circular in section with the doublure extending almost to the articulating line ventrally.

Remarks: Harrington and Leanza (1957) noted the similarity of this species to *L. manitouensis* Walcott, 1925 but the distinguishing features quoted by those authors now seem inappropriate. Only the length of the anterior border is distinctive of Walcott's (1925, pl. 21, figs 12-19) material but the illustrated material of Berg and Ross (1959) may be further distinguished by its extremely short palpebral lobe. *Leiothegium floodi* Shergold, 1975 appears separable only on the shorter anterior border and the possible synonymy of *L. floodi* and *L. manitouensis* deserves further consideration as the features quoted by Shergold appear not to be distinctive; the palpebral lobes are in precisely the same position in both species, and the glabellar furrows and eye ridges, which depend greatly on preservation, are faintly visible on one of Walcott's (1925, pl. 21, fig. 18) and both of the cranidia of Berg and Ross (1959) and these features may also change with growth.

***Leiothegium* sp. cf. *L. manitouensis* Walcott, 1925**

Plate 22, figures 11, 12

Material: Two cranidia NMVP74374 and 74375 from NMVPL184.

Remarks: Two damaged cranidia from the middle of the size range of specimens of *L. douglasi* exhibit extremely short anterior borders suggesting assignment to *L. manitouensis* as all other observable characters are comparable with the associated *L. douglasi* and the length of the border is the only feature distinguishing these two species as discussed above. However, since the specimens are distorted by lateral compression and as features of the palpebral

area are not known, I hesitate to make a definite assignment. These two cranidia also exhibit fine terrace lines on the anterior border near, and parallel to the margin.

Family CERATOPYGIDAE Raymond, 1913

Onychopyge Harrington, 1938

Type species (by original designation): *Onychopyge riojana* Harrington, 1938 from the early Tremadoc of Argentina.

Diagnosis: Glabella of low convexity, broad, with straight sides parallel to gently tapering forward; palpebral lobes long, semicircular, situated posteriorly close to axis; preglabellar field absent; anterior border short, strongly upturned, transverse to very gently curved on cranium; posterior cephalic limb short and very wide. Librigena with strong genal spine continuing the curve of the cephalic margin. Pygidium of variable shape, with pair of prominent marginal spines from anterior segment, extending posteriorly in most cases; axis of 5-7 segments, usually relatively short, with low median ridge extending from it posteriorly across border area; pleural area dominated by first segment, with well-impressed first pleural and interpleural furrows and wide anterior pleural band, with more posterior furrows indistinct or absent; border ill-defined by change of slope only; doublure wide, with prominent terrace lines.

Remarks: With the several species now described (Harrington & Leanza, 1957; Robison & Pantoja-Alor, 1968; Shergold, 1975; Benedetto, 1977; Zhou & Zhang, 1983; Peng, 1983) it is possible to provide a more extensive diagnosis than originally given.

The very close resemblance between *O. sculptura* Robison & Pantoja-Alor, 1968 and *Haniwa ambolti* Troedsson, 1937 suggests that reassignment of the latter species from central Asia may be necessary but I hesitate to do so until a pygidium can be associated with Troedsson's cranidium. Certainly the glabellar shape, palpebral lobes, and preglabellar structure more closely resemble *Onychopyge* than *Haniwa*.

The cranidium of *Macropyge chermi* Stubblefield figured by Owens *et al.* (1982, pl. 2h) closely resembles that of *O. parkerae* described

below (cf. Pl. 23, fig. 9 for glabellar furrows and early development of baccula) but Owens *et al.* (1982, p. 15) suggest an origin for *Macropyge* via *Aksapyge* Lisogor, 1977 which seems entirely reasonable. So *Onychopyge* and *Macropyge* are inferred to belong to separate lineages whose origins are presumably close together.

Homeomorphous similarities to the Kainellidae include the size and position of the palpebral lobes but most strikingly the pygidial structure (cf. Ross & Shaw, 1972, pl. 1) where the postaxial ridge, ridges on the pleural bands, wide terrace-lined doublure and posteriorly directed segments with well-impressed pleural furrows are evident. However the ceratopygid identity seems assured when compared with *C. forficuloides* Harrington & Leanza, 1957 and *C. forficula* Sars (see Moberg & Segerberg, 1906).

Onychopyge parkerae sp. nov.

Plate 23, figures 1-16; plate 24, figures 1-4

Etymology: The species is named for Charlotte Parker who assisted me with initial sorting and preparation of the collection.

Material: Holotype NMVP74392, paratypes NMVP74376 to 74391 and 74393 to 74395 from NMVPL184.

Diagnosis: Member of *Onychopyge* with subrectangular glabella bulging slightly laterally at level of lobe 2p, glabella reaching anterior border furrow; librigena with slightly advanced genal spine, coarse terrace lines on border and genal spine with chevron-shaped terrace lines over margin, with posterior border furrow entirely on librigena; thorax of more than eight segments with pleural tips spinose, with spines exsagittal at pygidium. Pygidium longer than wide, subrectangular; axis of five rings and terminus, with low postaxial ridge extending to posterior margin; pleural field with well-impressed first pleural and interpleural furrows defining slightly raised first segment extending into long marginal spine; with surface ornament of terrace lines on axis and proximal parts of pleural field also; posterior margin between spines only gently convex.

Description: Glabella of low convexity in both anterior and lateral profiles, subrectangular in

outline, with rounded anterolateral corners, bulging slightly near midlength adjacent to glabellar lobe 2p, with margins generally ill-defined by poorly-impressed axial furrow, with two or three pairs of faint lateral glabellar furrows evident in some specimens; furrow 1p round pit-like depression close to axial furrow, near rear of palpebral lobe; 2p furrow wider than long, angled posteroaxially from near axial furrow, extremely faint; furrow 3p just in front of anterior of palpebral lobe, running slightly anteroaxially from axial furrow, extremely faint; occipital ring of uniform length, gently convex in lateral profile, descending laterally without apparent division into posterior border; anterior border short, flat, rising up forward, of uniform length; anterior border furrow shallow but distinct, concurrent with preglabellar furrow, almost transverse on cranidium; palpebral lobe semicircular, narrow, defined by poorly-impressed palpebral furrow, flat so that posterior elevated above posterior cephalic limb and anterior elevated above anterior section of fixigena, both ends of lobe reaching axial furrow close to glabella; eye ridge not present; palpebral lobe terminating against outer margin of axial furrow; posterior cephalic limb wider than palpebral lobe, very short, with only posterior border and beginnings of slope into posterior border furrow included; facial suture diverging gently forward from the anterior of the palpebral lobe, transverse behind palpebral lobe before turning to margin at right angle. Librigena with high convex eye socle standing up vertically from smooth gently convex genal field; border furrow well-impressed, sharp and narrow anteriorly, becoming extremely wide posteriorly near genal spine (where it appears to bifurcate in one specimen (Pl. 23, fig. 13)) around an island before joining again at the genal angle, long and shallow along posterior; part of the posterior border also present on librigena laterally; border narrow and highly convex anteriorly, becoming less convex posteriorly, continuing posteriorly into long gently curved slightly advanced librigenal spine; spine with rounded cross-section, with prominent longitudinal terrace lines continuing along full length of lateral border; terrace lines at low

angle to margin, all turning sharply back in anteriorly-directed chevron-shaped turns all in line parallel to margin and on vertical marginal roll. Thorax of more than eight segments; articulating furrow transverse; articulating half-ring less than half length of axial ring; pleura with well-impressed furrow from anterior margin at axial furrow to midlength in articulating line then down posterior part of spines; free pleura with long spinose tip, transverse anteriorly, becoming exsagittal in front of pygidium. Pygidium longer than wide, subrectangular, flat except for markedly convex axis standing above pleural areas and weakly raised first segment on pleural field; axis of five rings and terminus defined by extremely poorly impressed transaxial furrows, with asymmetrical terrace lines having vertical posterior slope running across the top of each axial ring and quite a number on the terminus the latter extending on to the proximal parts of pleural field, occupying only a little more than half pygidial length, tapering to rounded posterior in overall inverted bell shape, continuing posteriorly in low postaxial ridge to or very near to posterior margin; axial furrow expressed as change of slope only; pleural field narrower than axis anteriorly, with anterior segment well defined by first interpleural furrow and slightly raised with distinct pleural furrow on it; anterior segment curved anteriorly from axial furrow so that in posterior part it is exsagittal, extended into long slender spine from posterolateral corner, with parallel longitudinal symmetrical terrace lines around entire circumference of spines; with two terrace lines on dorsal surface extending along crest of pleural bands of first segment as far as axial furrow; posterior margin between spines weakly convex with transverse central section; border and border furrow not evident; doublure extremely wide extending beneath almost entire pleural area and terminus of axis, small posteroproximal area of pleural area without doublure beneath it; doublure covered with prominent comarginal asymmetrical terrace lines having vertical posterior slope; terrace lines on underside of marginal spines extending forward on doublure to lateral margin or recurving posteriorly to parallel the posterior margin.

Remarks: *Onychopyge parkerae* may be distinguished from *Onychopyge assula* Shergold, 1975 from Queensland because that species has a pygidial border furrow and more distinct pygidial furrows in general. The fragmentary cranidium of the Queensland species prevents comparison of that shield. The Mexican species *O. sculptura* may be distinguished by its more rounded glabella anterior not extending so close to the border furrow, its better impressed transaxial furrows, more extensive development of terrace lines on pleural areas and strongly convex posterior margin between spines. It should be noted that the fragmentary librigena illustrated by Robison & Pantoja-Alor (1968, pl. 100, fig. 3) has the same peculiar border furrow as the Victorian species. Of the Argentinian species only *O. longispina* Harrington & Leanza, 1957 has comparable pygidial shape but it may be distinguished by the convex medially pointed posterior margin between the spines. *Onychopyge longispina* is the closest morphological match for *O. parkerae* of known species.

Although assignment of the thoracic fragment is not certain, the association with a pygidium of *O. parkerae* lying on the posterior of the thorax and prepared away to expose the thoracic pleural tips as well as the terrace lines laterally and the style of pleural furrows in comparison with that on the pygidium give considerable confidence to the assignment.

Family KAINELLIDAE Ulrich & Resser, 1930

***Pseudokainella* Harrington, 1938**

Type species (by original designation): *Pseudokainella keideli* Harrington, 1938 from the Late Tremadoc of Argentina.

Diagnosis: Kainellids with glabella tapering gently forward to broadly truncated anterior, may be laterally swollen between palpebral lobes or constricted at level of junction of palpebral lobe with axial furrow; prelabellar field of variable length both through ontogeny and between species; interocular cheeks narrow with palpebral furrow merging with or coming close to axial furrow; palpebral lobes long and crescent-shaped; angle of divergence of facial

suture forward of palpebral lobe variable within and between species. Librigena wide, with long normal or advanced genal spine. Thorax of 12 segments; eighth ring bearing long posterior spine; pleural tips spinose. Pygidium elliptical to quadrate in outline; axis of two to four rings and terminus, standing high above pleural areas, not reaching margin; pleural area with three or four pleural furrows; interpleural and border furrows faint; anterior pleural band of each segment extended into three, four or five pairs of free marginal spines decreasing in size posteriorly.

Remarks: Ludvigsen (1982b) erected *Elkanaspis* for a group of American species that had earlier been referred to *Pseudokainella* (Shergold, 1975; Taylor, 1976) but of the five features that he quoted to distinguish the two genera the new Victorian species described below gives reason to remove three and the other two may reasonably be considered specific taxobases. In *P. diggerensis* the smaller cranidia (Pl. 25, fig. 3) lack a prelabellar field as in three illustrated specimens of *P. keideli* (Harrington & Leanza, 1957, fig. 52-5, 7, 10) that are of comparable size but in larger specimens (Pl. 24, figs 5, 11) the prelabellar field appears and becomes progressively longer with increasing size. In the larger holotype of *P. keideli* (Harrington & Leanza, 1957, fig. 52-6) the prelabellar area is obscured by matrix but from the position of the anterior border it would seem that a short field may be present. Although some species may be uniform in this feature (e.g., *Elkanaspis futile* Ludvigsen, 1982b) the fact that the two states exist in the ontogenetic series of one species makes it an extremely doubtful generic taxobase at least until considerably more is known about ontogenetic development in other species of the genus. In *P. diggerensis* even after allowing for distortion, the angle of divergence of the anterior parts of the facial suture varies from that shown by *E. futile* (i.e., at about 30 degrees to exsagittal line) (Pl. 24, fig. 6) to almost transverse (Pl. 25, fig. 2); therefore this feature which also varies considerably due to tectonic distortion should not be used as a generic taxobase in this case. Ludvigsen (1982b) has attached significance to

the anterior constriction of the glabella but once again *P. diggerensis* shows a considerable range of variation in development of this feature. Moreover the constriction is associated with the point at which the anterior end of the palpebral lobe reaches the axial furrow so that it is at the anterior in *E. futile* only because that is where the palpebral lobe ends. In *P. diggerensis* and other species the palpebral lobe reaches the axial furrow well back from the anterior of the glabella and the constriction is removed posteriorly accordingly. I submit that this is not a suitable generic taxobase because of the intraspecific variation in *P. diggerensis*. I consider the posterior merging or otherwise of the palpebral and axial furrows to be a specific taxobase not of generic significance, because in the related genus *Richardsonella* Raymond, 1924 there are species with these two furrows merging (e.g., *R. aretostriatus* Raymond, 1937, pl. 1, fig. 6) and others (e.g., *R. laciniosa* Shergold, 1971, pl. 6, fig. 2) where they do not merge. Moreover, Ludvigsen (1982b) appears to concede that this may not be a generic taxobase when he is not prepared to separate *P. lata* Harrington & Leanza, 1957 with the furrows merging from *P. impar* (Salter) in which the two furrows are clearly not merging (Whitworth, 1969, pl. 75, fig. 5). The macropleural pygidial spine is a valid taxobase of *P. keideli* but is unlikely to be a generic taxobase especially in the absence of support from the other features quoted. For these reasons *Elkanaspis* could be considered a junior synonym of *Pseudokainella* but that question is tied to the more difficult problem of the limits of the genus *Richardsonella* Raymond, 1924 which has been discussed by Palmer (1968). Palmer suggested generic groupings based on the pygidia and in particular on the length and composition of the axis and the length of the marginal spines; interestingly the two species quoted by Palmer as provisional types were included by Ludvigsen (1982b) in his genus *Elkanaspis* apparently mainly on cranidial features. Palmer mentioned the multisegmented pygidial axis of his species *R. quadrispinosa* and the paucisegmented short axis of *R. unisulcata* Rasetti, 1944 as representing two generic groups but the four and three axial rings respectively of these two species are

only part of a series from *P. futile* with two through *P. diggerensis* with two and sometimes a weak third. The length and direction of the marginal spines is seen to vary with growth in *P. diggerensis* so that feature must be considered of doubtful value as a generic taxobase. Given the difficulty of interpreting the type species of *Richardsonella* and the fact that the best preserved specimen upon which the concept of *Pseudokainella* has been commonly based (Harrington & Leanza, 1957, fig. 52-5) is a juvenile individual (with the holotype more poorly preserved and illustrated) the assignment of a considerable number of species is very doubtful at present. Whereas the pygidia of *P. diggerensis* and *R. quadribrachiatus* or the cranidia of *P. keideli* and *P. futile* may appear quite distinct they must be viewed in the broader spectrum of species morphologies and it is in this light that generic distinctions have not yet been convincingly established. For the present I concur with Shergold (1971) and Taylor (1976) in assigning most of these North American species to *Pseudokainella* as an interim measure. *Elkanaspis* is considered a junior subjective synonym of *Pseudokainella*. This synonymy should be reviewed again when a fuller size range is available for more of the species involved, in particular for *P. futile*, *P. keideli* and the other Argentinian species.

I do not accept that the posterior cephalic margin of *P. futile* runs forward from the axial furrow as depicted by Ludvigsen (1982b, fig. 38) as the librigenae illustrated by Ludvigsen (1982b, fig. 64N, O) show clearly that the posterior part of the facial suture is transverse or even running posterolaterally from the posterior of the palpebral lobe and the posterior margin of the posterior cephalic limb which parallels the suture must be transverse or at only the very slightest angle to transverse; considering the articulation of the first thoracic segment it must be assumed to have been transverse. Similarly I do not accept the reconstruction of *P. impar* provided by Whitworth (1969, fig. 1a) with the posterior of the cephalon lying over the first and most of the second thoracic segments. The specimen upon which this reconstruction is based (Whitworth, 1969, pl. 75, figs 7, 8) shows clearly that the

posteroproximal corner of the librigena has overridden the axial furrow onto the glabella, particularly on the lefthand side and that there has been dislocation along the anterior section of the facial suture. This anticlockwise rotation of the left librigena to greater degree than the clockwise rotation of the right librigena is illustrated by the genal spine being closer to the thorax on the left side than on the right. The overriding and dislocations of this specimen probably occurred during moulting or compaction of the sediment and the relationships of the various parts during life may safely be assumed to have been the normal trilobite arrangement with a transverse posterior margin to the cephalon opposed to a transverse anterior margin on the first thoracic segment as far as the articulating line.

Cranidial features of *Fatocephalus* Duan & An (in Kuo *et al.*, 1982) from available description and illustration fall within the generic morphotype of *Pseudokainella*. Although no pygidium has been assigned to any species of *Fatocephalus* it is considered a junior subjective synonym of *Pseudokainella* pending its further understanding.

***Pseudokainella diggerensis* sp. nov.**

Plate 24, figures 5-14; plate 25, figures 1-13

Etymology: The species is named for Digger Island where the fossils were collected.

Material: Holotype NMVP74416, paratypes NMVP74396 to 74415, 74417, and 74418, from NMVPL184.

Diagnosis: Member of *Pseudokainella* with glabella constricted slightly at junction of axial furrow with eye ridge some distance (almost a quarter of the length) behind glabellar anterior; preglabellar field absent in small specimens (cranidia 3 mm long) increasing in length with growth; anterior border furrow with row of conspicuous perforations apparently matching a set on the doublure of librigena; anterior border becoming shorter with growth; palpebral lobes extremely close to glabella, enclosing tiny interocular cheeks, with palpebral furrow merging with axial furrow both anteriorly and posteriorly; librigena with advanced genal spine and long forward extension of doublure

to median connective suture. Pygidium transverse; axis of two well-defined rings and terminus, extending to inner edge of doublure as low postaxial ridge, with terminus weakly divided by further transaxial furrow in some specimens; pleural area with three pleural furrows and one interpleural furrow weakly impressed; border narrow, with four or five pairs of marginal spines directed either posteriorly or curving posteroaxially with curvature increasing posteriorly.

Description: Glabella subrectangular to tapering gently forward, with slight lateral bulge between palpebral lobes and slight constriction at level of anterior of palpebral lobe, with rounded anterolateral corners and transverse preglabellar furrow, with three pairs of faint lateral glabellar furrows rarely apparent, strongly convex decreasing in larger specimens; glabellar furrows short and wide, at low angle to transverse, with 3p meeting axial furrow near anterior of palpebral lobe; occipital ring moderately long, flat in lateral profile, with almost imperceptible anteromedian node on external surface of exoskeleton, tapering laterally in most abaxial parts; occipital furrow shallow and curving forward laterally, transverse medially; axial furrow distinct as a marked change of slope for most of its course but well impressed between palpebral lobes, concurrent with palpebral furrow or with small narrow island in middle of furrow representing last remnant of interocular cheek, shallower near midlength of palpebral lobe than at ends; preglabellar field absent to less than half length of border in smaller specimens but considerably longer in larger specimens, sloping forward but actual angle of inclination not certain due to distortion; anterior border of variable length, generally longer in smaller specimens but also considerably affected by distortion, tapering laterally along facial suture; palpebral lobe very close to glabella, with both ends reaching axial furrow, arcuate, situated near midlength of glabella, widest near midlength, tapering more to anterior than to posterior, gently convex in section; posterior cephalic limb wide and short, with well-impressed border furrow, short fixigenal spine at extremity; facial suture

diverging forward from palpebral lobe at approximately 45 to 60 degrees to transverse, (variations in this angle are due to distortion of the exoskeleton during compaction and subsequent tectonic disturbance), running across border at very low angle to anterior margin to sagittal line then over anterior margin as median connective suture, running just behind transverse from posterior of palpebral lobe and meeting posterior margin in acute angle. Librigena wide, sloping gently into border furrow; eye socle, low, arcuate, differentiated from genal field by marked change of slope only; border furrow well-impressed, turning through an obtuse angle at base of genal spine; border convex, of uniform width, with fine comarginal terrace lines near margin; genal spine advanced, curving gently adaxially towards tip, circular in section, with fine longitudinal terrace lines near base; doublure, convex in section, with fine terrace lines well developed, extending forward to median connective suture, with row of pits along inner margin of this extension corresponding to pits in border furrow on dorsal side (so exoskeleton is perforated along this line).

Thorax of 12 segments with prominent long median spine on eighth segment; articulating halfring longer than furrow, tapering only slightly laterally; articulating furrow well impressed, almost U-shaped in section, with lateral apodemal pits, curving forward over sagittal line; axial ring longer laterally than sagittally, with posterior margin curving forward over axis; pleural furrow having steep anterior wall and gentler posterior wall, running from axial furrow at anterior margin to midlength at articulating line, straight and well impressed; free pleura extended in short spine, curving gently back with curvature increasing posteriorly; doublure on free pleura extending adaxially almost to articulating line.

Pygidium transversely semioval, relatively flat except for markedly convex axis standing high above pleural areas; axis of three axial rings with prominent pseudoarticulating halfrings; first two transaxial furrows well impressed, third very weak and often not evident; rings with prominent pseudoarticulating halfrings; first two transaxial furrows well impress-

ed, third very weak and often not evident; pleural area with two anterior pleural and first interpleural furrows distinct, more posterior furrows indistinct, pleural furrows running laterally to gap between first two marginal furrows (although one specimen (Pl. 25, fig. 9) shows it running onto the spine); border furrow shallow, not always evident, discontinuous behind axis; border of uniform width, weakly convex, with comarginal terrace lines, bearing four of five pairs of marginal spines; marginal spines of variable length but never very long, decreasing in length posteriorly, directed posteriorly or curved adaxially especially near the axis at the rear, varying from a flat section anteriorly to rounded at rear, evenly spaced except for posterior pair which are very close together when five pairs are present but well separated when only four are present; doublure narrow, with comarginal terrace lines.

Remarks: This species seems to be most similar to the Canadian *P. futile* and the Chinese species mentioned below but may be distinguished from the former by its virtual lack of glabellar furrows, prominent anterior border pits and generally longer pygidial marginal spines. *Fatocephalus latus* Duan & An in Kuo *et al.*, 1982 from north China appears very similar to *P. diggerensis* being distinguished only by its palpebral lobes reaching the axial furrow closer to the glabellar anterior. However, the Chinese species is illustrated only by two distorted cranidia so full comparison is impossible. The Argentinian species *P. lata* and *P. keideli* may also be distinguished by the glabellar furrows and pygidial spine arrangement.

Family HARPEDIDAE Hawle & Corda, 1847

Australoharpes Harrington & Leanza, 1957 has been assumed to be the most primitive harpedid because of its age. However, the discovery of *Brachyhipposiderus* gen. nov. in association with *Australoharpes* in the early Tremadoc of Victoria, probably contemporaneous with the Argentinian *A. depressus*, and some of the characteristics of *Brachyhipposiderus* suggest that it may well be the more primitive harpedid and may have evolved from the Late Cambrian

Entomaspis Ulrich in Bridge, 1930. Particularly important is the short prolongation which is very similar to that of *Entomaspis* (Rasetti, 1952) and to that of juvenile harpedids (Chatterton, 1980). The facial suture on *Brachyhipposiderus* is similar to that on *Entomaspis* in that it leaves the genal spine on the lower lamella and the only difference is that the re-entrant to the eye tubercle in *Entomaspis*—a feature that was obsolescent and apparently without functional value—has been lost completely. Although there are some other features of difference and the lineage certainly did not evolve directly between the two known species there are sufficient features in common to suggest that the Entomaspidae gave rise to the Harpedidae and that *Brachyhipposiderus* was close to the origin of the latter family. This position for *Brachyhipposiderus* is supported by the retention of most of its adult characters in juveniles of younger harpedids (Chatterton, 1980).

Whereas Rasetti (1952) suggested that *Entomaspis* may be an ancestor to the Trinucleidae the less regular but still radial pitting of the brim, lower overall cranial convexity, strongly developed girder, weakly developed alae, and glabellar and palpebral organisation of *Brachyhipposiderus* all suggest that *Entomaspis* gave rise to the Harpedidae.

***Brachyhipposiderus* gen. nov.**

Etymology: From the Greek *brachys* meaning short and *hipposideros* meaning horseshoe and referring to the abbreviated prolongation which develops into an elongate horseshoe shape as in *Australoharpes* and *Scotoharpes*.

Type species: *Brachyhipposiderus logimus* sp. nov. from NMVPL184.

Diagnosis: Cephalon sub-semicircular; 1p furrow well impressed; alae distinct but low; occipital tubercle prominent; radial anastomosing caecal network on cheeks and brim with moderately large pits between caeca on brim gradually decreasing towards glabella; brim prolonged only a very short distance behind posterior of occipital ring, markedly concave posterolaterally; long genal spine at rear of prolongation; girder prominent, extending to tip of

prolongation; cheek roll widened at level of posterior border furrow, extending adaxially almost as far as exsagittal line of outer edge of eye tubercle.

Remarks: The distinctive features of this genus are its abbreviated prolongation, consequent semicircular shape and long strong genal spine. As discussed above, these features reflect its place at or near the base of the radiation of the harpedids. Only the course of the facial suture, not reaching the eye tubercle, prevents this genus from being classified in the Entomaspidae.

***Brachyhipposiderus logimus* sp. nov.**

Plate 26, figures 1-8

Etymology: From the Greek *logimus* meaning notable and referring to its importance in harpedid phylogeny.

Material: Holotype NMVP74419, and paratypes NMVP74420 to 74426 from NMVPL184.

Diagnosis: As for genus.

Description: Cephalon semicircular to semi-ovate, of relatively low convexity, with central part (i.e. within the girder) somewhat sunken by virtue of the concave distally-upturned brim. Glabella tapering gently forward to a broadly rounded anterior, strongly convex with almost vertical flanks in anterior profile, sloping in lateral profile in both directions from the high point just lower than eye tubercles near its midlength; 1p furrow well impressed on lateral slope of glabella, at low angle to exsagittal line, slightly offset abaxially then joining occipital furrow adaxially to isolate convex almost bean-shaped 1p lobe; 2p furrow barely evident as slight indentation in axial furrow at level of eye tubercles; occipital furrow long, shallow, with gentle anterior and posterior walls in medial section, with deeper apodemes having steep anterior wall behind 1p lobes, running transversely; occipital ring from virtually nothing at axial furrow to quite elongate medially, with evenly curved posterior margin, with prominent median tubercle close to occipital furrow. Axial furrow well impressed but shallowing forward, with usually much gentler rises to the cheeks than up the near-vertical

glabellar sides, with steep slope abaxially up to eye tubercles. Preglabellar field relatively short but longer than cheek roll in sagittal line, gently convex, not expanded into a boss. Cheeks convex, with radial caecal network well developed; alae small, semicircular, smooth, depressed a little below rest of cheek, rising with the cheek abaxially; eye tubercles, situated well behind glabellar anterior opposite 2p furrow, surmounting highest points of cheeks, elevated above cheeks and just above highest point of glabella, with steep adaxial side continuing slope up from axial furrow so tubercle appearing to lean abaxially, with concave abaxial slope, with visual surface apparently on upper part of abaxial side; eye ridge distinct, consisting of two strong caeca widely separated (by 1 or 2 mm) and posterior one transverse but anterior one markedly oblique from near glabellar anterior. Cheek roll relatively low, with fine ridge around inner margin, adaxially only a short distance along posterior border and down prolongation the same distance as the brim. Posterior border furrow well-impressed, of uniform length, with gentle anterior wall but steep posterior wall; posterior border highly convex, short, of uniform length, with angular bend near its midwidth, distal part running back to end of prolongation. Brim of uniform width, concave in radial profile especially posterolaterally, with outer part much higher than girder, with gentle arch over sagittal line and lateral parts most ventral in anterior profile, with well developed radial anastomosing caecal network having intervening pits of fairly uniform size; outer rim upturned quite high dorsally but not projecting ventrally, with distinct furrow on the marginal band apparently accommodating the facial suture; girder distinct, extending ventrally a short distance from brim in particular over the sagittal arched section, extending to tip of prolongation, with strong caeca running into it or out of it on both sides; prolongation very short (less than 0.2 of cephalic length), highly concave, sunken between high rims; genal spine strong, long, directed posterolaterally; facial suture running up from marginal band anterior to the genal spine, crossing the outer rim and descending into posterior of prolongation, crossing posterior

border (or inner rim) just in front of genal spine.

Remarks: All available specimens are distorted in some way so that the description is based on a number of specimens. The holotype is fractured on the left side with the genal spine and posterior of brim pushed adaxially over parts of the cheek so giving a narrower shape to the cephalon; it is also distorted and fractured in the preglabellar area. Although in discussion of *Australoharpes singletoni* sp. nov. I caution against too much use being made of convexity of brim, the degree of upturning to the outer part of the brim and its uniformity through so many specimens are such that it must be a consistent character and must have considerable significance. If this upturning were tectonically induced a great deal more fracturing of the brim would be evident.

The specimens are preserved in very soft mudstone which has had to be hardened with dilute bedacryl solution to allow latex casts to be taken; this treatment decreases penetration by or absorption of the latex, and this accounts for the greater than normal number of air bubbles in finer structures.

Australoharpes Harrington & Leanza, 1957

Type species (by original designation): *Australoharpes depressus* Harrington & Leanza, 1957 from the *Parabolinella argentina* and *Kainella meridionalis* zones of the Tremadocian sediments in Salta and La Rioja Provinces of Argentina.

Remarks: This genus is very closely related to the European *Eoharpes* Raymond 1905; indeed taking into consideration the several morphological features of the new Australian species described below a strong case may be put for synonymy of the two genera. Although I choose to retain the two names for the time being, only the size of the pits in the brim appears to retain any validity as a generic taxobase and on its own, that seems an inadequate determinant. Other features quoted by Harrington & Leanza (1957, p. 195) as distinguishing *Australoharpes* from *Eoharpes* (namely development of eye ridges, slight difference in position of eyes, and possession of

a preglabellar boss) are almost certainly minor specific features. The wide genal roll, quoted as distinctive of *Eoharpes*, is present in *A. expansus* so eliminating that distinction. For the moment *Australoharpes* is distinguished by its smaller pits in the brim, lack of eye ridges, more anteriorly situated eyes, and a preglabellar median swelling.

***Australoharpes singletoni* sp. nov.**

Plate 27, figures 1, 3-8

Etymology: The species is named for Dr O. P. Singleton who first identified trilobites from Digger Island in Lindner's (1953) paper on the geology of the area.

Material: Holotype NMVP74427, paratypes NMVP74429 to 74435 all from NMVPL184.

Diagnosis: Member of *Australoharpes* without alae; eye tubercles situated behind glabellar anterior; preglabellar boss extremely low; girder fading out just before tip of prolongation; spine present on tip of brim prolongation; cheek roll on prolongation relatively wide; thorax of at least 18 segments.

Description: Exoskeleton elongate oval, with convex central cephalic area, thorax, and pygidium standing well above brim. Glabella tapering very slightly forward to a rounded anterior, raised above cheeks posteriorly, strongly convex in anterior profile; 1p furrows poorly impressed, low on glabella at axial furrow, at low angle to exsagittal line in postero-axial direction. Occipital furrow transverse, short, distinct, shallow; occipital ring flat in lateral profile, elongate sagittally to more than twice lateral length, with evenly curved posteriorly-convex posterior margin, its doublure approximately half length of ring. Preglabellar field very weakly inflated into a boss as is cheek roll in front of the glabella; inflation of the cheek roll sagittally extending it slightly forward into brim so breaking even curve of girder. Axial furrow well impressed laterally, shallowing forward and represented only by a change of slope in front of the glabella, with much lower slope out of axial furrow away from glabella than onto glabella. Eye tubercles relatively large and prominent, standing higher than anterior of glabella,

situated with anterior behind glabellar anterior, longer than wide, with indistinct longitudinal furrow along the vertical abaxial slope near its mid height and a more distinct furrow at the base of the abaxial slope swinging around anterior and posterior ends; palpebral lobe flat and highly arcuate; visual surface apparently over upper half of lateral slope, of uniform width, highly arcuate (Pl. 27, figs 1A, 3A). Girder horizontal, not projecting below brim at all, extending along the prolongation before running into the inner rim some distance (2 mm in cephalon 27 or 38 mm long) from the tip of the brim prolongation. Cheek roll relatively low around cheeks, slightly higher on either side of preglabellar boss anteriorly, lowest anterolaterally then highest at the level of the posterior border furrow and anterior part of prolongation, tapering rapidly along prolongation. Brim with irregularly-radial repeatedly-anastomosing caeca leaving only very fine pits between them, horizontal to gently concave, of even width except for tapering end of prolongation and sagittally as described above, with spine on posterior end of prolongation. Outer rim strongly upturned dorsally but not projecting ventrally, with only very low outer vertical marginal band bearing the suture. Hypostome unknown.

Thorax of at least eighteen segments, tapering posteriorly, with convex axis, horizontal pleurae within fulcral lines and steeply downturned pleural extremities; axis with shallow distinct articulating furrow, short articulating half ring only slightly lower than axial ring, with posterior margin of axial ring curving very gently forward over medial part of axis. Pleurae with well impressed pleural furrows running in midlength of segment throughout to finish against well developed articulating facets near the midlength of the facet; articulating facet large, half segment length, flat; pleural tip apparently rounded. Pygidium unknown.

Remarks: *Australoharpes singletoni* may be distinguished from the type species by its posterior eyes, its less developed alae, its higher cheek roll and spine on the tips of the prolongation although available illustrations do not preclude their presence in *A. depressus*. It

should also be noted that the girder in *A. depressus* appears (Harrington & Leanza, 1957, fig. 103-3) to terminate just before the tip of the prolongation as in *A. singletoni*.

One specimen (Pl. 27, fig. 1A) shows the outer brim distinctly flexed, not fractured, where it is lying on an exoskeletal fragment of another trilobite. This suggests strongly that there was a certain amount of flexibility in the brim which may have been the case with harpedids in general.

***Australoharpes expansus* sp. nov.**

Plate 27, figure 2; plate 28, figures 1-10

Etymology: From the Latin *expansus* spread out—referring to the expanded brim.

Material: Holotype NMVP74439, paratypes NMVP74428, 74436, 74438, 74440-74444 all from NMVPL184.

Diagnosis: Alae absent; eye tubercles small, situated level with anterior of glabella; preglabellar boss present; girder fading out just before tip of prolongation; brim wide anteriorly, tapering rapidly along relatively short prolongation; spine present on tip of prolongation.

Description: This species is described only where it differs from *A. singletoni*.

Glabellar furrow 2p is impressed low on side of glabella just forward of 1p. Eye tubercles small, situated level with glabellar anterior, circular, joined to glabella by faint eye ridge, without furrows. Cheek roll very low except at posterior border furrow where it is more than twice as high as at anterior but lower than in *A. singletoni*. Brim wide anteriorly but tapering markedly posteriorly, with generally less distinct outer rim, flat with only slightly upturned margin (if at all), with relatively short prolongation, pointed posteriorly and with only short posterior spine.

Thorax, pygidium and hypostome unknown.

Remarks: This species is much closer to *A. depressus* Harrington & Leanza, 1957 than *A. singletoni* in so far as the brim is flat and wide, the eye tubercles are further forward and the cheek roll is quite low; it is distinguished from the Argentinian species by its lack of alae, its short tapering prolongation and impression of glabellar furrows.

Family PILEKIIDAE Sdzuy, 1955

The affinities of the pilekiids were shifted from the Pliomeridae (Harrington *et al.*, 1959) to the Cheiruridae (Whittington, 1961; Lane 1971) and there is little doubt that the Pilekiidae gave rise to the Cheiruridae. However, Lane's (1971) placement of the pilekiids as a subfamily of the Cheiruridae failed to consider any possible relationship between the pilekiids and pliomerids which might have an effect on the family classification of these groups. Even without any phylogenetic considerations the Pilekiidae may be distinguished from the Cheiruridae by the style of pleural furrows on the thorax and pygidium (as noted by Lane (1971)) and by the usual four pairs of pygidial spines as opposed to three or fewer in the Cheiruridae. A few exceptions to the latter distinction are noted but affinities of these genera are clear from the full morphology of each. It should also be noted that a number of pliomerid species "fall naturally into the diagnosis of the Cheiruridae" provided by Lane (1971) (e.g., *Protopliomerops quattuor* Hintze, 1953, *Pliomera tmetophrys* Harrington & Leanza, 1957).

The very clear pilekiid affinities of *Rossaspis* Harrington, 1957 have been demonstrated by Demeter (1973) through his species *R. pliomeris*. The four pairs of pygidial spines, retention of extremely short anterior pleural bands on pygidial segments, thoracic pleural furrows, large fixigenal spine and size and position of the palpebral lobe are unmistakably pilekiid and I agree with Demeter (1973, p. 53) that *R. pliomeris* and *R. superciliosa* show affinities to the Pilekiidae and Pliomeridae respectively. However, I suggest that rather than giving rise to the pilekiids *R. pliomeris* has evolved from the Pilekiidae (older pilekiids are known e.g. in the fauna described herein) and is an offshoot from the lineage that gave rise to *Protopliomerops* and the Pliomeridae. Providing the correlation of the Digger Island Formation given above is correct, the initial evolution of *Rossaspis* to the Pliomeridae occurred elsewhere sometime in the earliest Tremadoc and *R. pliomeris* may have been the first immigrant to reach the Great Basin. The similarity between *R. pliomeris* and *Protopliomerops lindneri* sp. nov. also suggests that this mor-

phology is close to the origin of the Pliomeridae.

The suggestion of Demeter (1973) that *Rossaspis* gave rise to the Pilekiidae would imply that thoracic pleural furrows developed strongly in the Pilekiidae and then disappeared again in the Sphaerocoryphinae. However, my suggestion that the Pilekiidae gave rise to both the Cheiruridae and Pliomeridae implies a reduction and loss of thoracic pleural furrows in at least two descendant lineages with marked modification in others.

Given the ability to distinguish pilekiids and given this possible phylogeny, with another family involved which is also distinguishable, I prefer to retain the Pilekiidae as a distinct family. The three related families may be grouped into some suitable higher-level taxon such as the Suborder Cheirurina Harrington & Leanza, 1957 as has been proposed previously (Harrington *et al.*, 1959).

Landyia gen. nov.

Etymology: The genus is named for Mr Tony Landy and family who own the adjacent property and facilitated my collecting; the specific name for the type species is given for his wife Mrs Elizabeth Landy.

Type species: *Landyia elizabethae* sp. nov.

Diagnosis: Small pilekiid with highly convex anterior profile; glabella tapering very slightly forward to broadly rounded anterior, with three pairs of sharp slit-like lateral furrows; glabellar furrows at low angle to transverse line for most of their width but curving strongly posteriorly in most adaxial part, with 3p having short often indistinct anterior fork or expansion; palpebral lobes short, far from axial furrow; posterior cephalic limb long and wide. Thorax of 13 segments; pleurae with sharp, slit-like pleural furrows running along the midlength of the segment for most of course, fading out just beyond articulating line; pleural tips broad, flat, curved posteriorly, with posterolateral projection into short spine.

Pygidium with axis of four rings and long triangular terminus reaching posterior margin but otherwise entirely enclosed by fourth pygidial segment; pleural and interpleural fur-

rows sharp and slit-like; interpleural furrows running to margin; posterolateral corners of segments extended into short flat spines, with spines becoming longer on more posterior segments.

Remarks: As with many pilekiid and pliomerid genera the distinctive features of this new taxon are to be found in the pygidium and thorax rather than the head. Most distinctive of all are the pleural furrows, marginal spines and completely surrounded axial terminus. On the cranidium the combination of an anterior fork in furrow 3p, the curved adaxial end of furrow 1p, lack of genal spine, large fixigena, and almost transverse eye ridge are a unique combination of characters but each is found in at least one other pilekiid genus. Relationships with known genera are impossible to discern as the style of pleural furrow and pygidial structure appear to be completely new in the family.

Landyia elizabethae sp. nov.

Plate 30, figures 5-11; plate 31, figures 1-5

Material: Holotype NMVP74474, paratypes NMVP74463-74473 from NMVPL184.

Diagnosis: As for genus.

Description: Cranidium convex in anterior profile, with anteriorly sloping frontal glabellar lobe, with smooth surface except for punctate cheeks having small granules in some places on the ridges between the pits; glabella narrowest at base of lobe 1p, widest at anterior of lobe 1p then parallel-sided or very weakly tapering forward to broadly rounded anterior, with three pairs of sharp slit-like and very wide lateral glabellar furrows; furrows 1p and 2p at low angle to transverse line, slightly sigmoidal, with adaxial end curving posteriorly with 1p furrow not reaching occipital furrow but nevertheless lobe 1p often somewhat bulbous and rounded (as in *Pilekia*); furrow 3p straight, parallel to central portion of 2p, with slight expansion in length abaxially where an anterior fork is barely preserved; lobes 1p, 2p, and 3p of equal length, with frontal lobe subtriangular and longer than others; occipital furrow short and deep, curving very gently forward at abaxial ends and over axis; occipital ring with transverse posterior margin except for slight anterior curve abaxial-

ly, with flat lateral profile medially but convex laterally; preglabellar furrow absent; axial furrow relatively narrow, with deep pit just anterior to eye ridge, appearing scalloped around glabellar lobes in most specimens; anterior border shorter than occipital ring, becoming more elongate near anterolateral corners of glabella; eye ridge meeting axial furrow at level of posterior of frontal glabellar lobe, transverse or sloping gently posterolaterally, of uniform length, continuing directly into palpebral lobe; palpebral lobe situated anteriorly opposite lobe 3p, palpebral furrow slit-like, continuing behind eye ridge to axial furrow; facial suture proparian, with anterior section running across border at very low angle to meet margin close to sagittal line, posterior section running almost transversely from posterior of palpebral lobe to meet margin well in front of genal angle; fixigena as wide as glabella, relatively large; posterior border furrow short, sharp, becoming less distinct around genal angle; posterior border becoming elongate laterally, quite wide at genal angle, without genal spine but with angular extremity in some specimens.

Hypostome longer than wide, with strongly convex median body bearing ornament of close-spaced fine granules most obvious on anterior part and decreasing in granule size laterally and posteriorly; anterior margin transverse to gently arched forward, depressed dorsally over axis; anterior wings triangular, bent strongly dorsolaterally, smooth, with broad shallow furrow adjacent to median body cutting off distal part; median furrow at very high angle to transverse line, curving and fading out adaxially to define the large inflated anterior lobe and short sloping horseshoe-shaped posterior lobe of the median body; lateral and posterior border narrow, of uniform width, raised and convex, with fine granulose ornament, beginning just behind the lateral notch on the very posterior of the anterior wing as a low rising ridge; border furrow well-impressed, very narrow laterally adjacent to the anterior of the lateral border, becoming wider and deeper posteriorly.

Thorax of 14 segments, strongly convex, with axis approximately as wide as each pleural field

in dorsal view; articulating half ring short, much lower than axial ring, merely a flange rising up from the anterior of the well-impressed almost transverse articulating furrow; axial ring of uniform length, gently convex in lateral profile; axial furrow expressed only as a change of slope from axis to pleura; pleura crossed by short slit-like pleural furrow running from the axial furrow just in front of the midlength of the segment along the midlength of the pleura and fading out beyond the articulating line well before the pleural tip, strongly downturned in articulating line, swung posteriorly with amount of swing increasing posteriorly to be almost exsagittal at pygidium; pleural tips pointed but not spinose, with wide steeply inclined weakly concave articulating facets.

Pygidium subtriangular, with lateral margins downcurved and posterior sloping back only gently with four pairs of marginal spines; axis of four rings and large triangular terminus, only gently convex in anterior profile, wider than each pleural field; anterior ring longer laterally than axially; second ring with prominent pseudoarticulating half ring; each ring very broadly convex forward; axial furrow weakly impressed but distinct, running in zig-zag out to the pleural furrow then adaxially back to the next posterior transaxial furrow; terminus elongate triangular, completely enclosed by the fourth segment except for posterior tip reaching posteromedial margin; transaxial furrows well-impressed and distinct anteriorly becoming shallower but still distinct posteriorly; pleural area crossed by short slit-like pleural and interpleural furrows, convex with downturned margin, without border furrow and border; interpleural furrows curving posteriorly with first at about 45° to transverse and third almost exsagittal, reaching lateral margin between spines; pleural furrows almost straight, near or just behind midlength of segment, finishing laterally soon after crossing articulating line well inside tips of segments; four pairs of marginal spines posterolaterally, with posterior pair longest, with spinose tip central rather than posteriorly on segment; pleural ribs short near axial furrow, becoming longer near articulating line then tapering to tip (fourth segment in particular, with this shape).

Victorisipina gen. nov.

Etymology: The generic name refers to the spinose nature of the exoskeleton found in Victoria.

Type species: *Victorisipina holmesorum* sp. nov.

Diagnosis: Pilekiid with extremely long fixigenal spine issuing from posterior cephalic border at the articulating line, with opisthoparian facial suture, without genal spine, with parallel-sided subrectangular glabella bearing three pairs of wide short slit-like glabellar furrows, with furrow 3p having short but distinct anterior fork, with long upwardly-directed slightly reclined spines situated on each thoracic segment in the articulating line, with transverse pygidium having four pairs of posteriorly directed marginal spines, with anterior band of each pygidial pleural rib greatly reduced in favour of the posterior band which is elongate into the marginal spine, and with extremely coarse granulose ornament over entire exoskeleton except for furrows and spines.

Remarks: This genus has a combination of features some of which are known in *Pilekia* Barton, 1915 and others which are characteristic of *Parapilekia* Kobayashi, 1934; however the opisthoparian facial suture and position of the fixigenal spine may prove to be unique to this genus. *Victorisipina holmesorum* has the glabellar shape, style of glabellar furrows, and reduced anterior pleural bands of pygidial pleural ribs characteristic of *Parapilekia* Kobayashi, 1934, but that genus has proparian facial suture, genal spine, and presumably lacks thoracic spines in the articulating line. *Pilekia apollo* (Billings, 1860), has the spines in the articulating line on the thorax (seen on specimen figured by Raymond (1913, pl. 4, fig. 1) from photographs kindly provided by Dr T. E. Bolton), but has distinctive glabellar features and has the anterior band of each pygidial pleural rib much less reduced relative to the posterior band. Other genera of Pilekiidae may not be confused with this genus and need no comment. The doubly spinose thoracic pleurae are reminiscent of a number of

odontopleurid genera but any phylogenetic links must be discounted and the resemblance attributed to homeomorphy as the major cephalic spines consistently arise from different positions in each group.

As some species of *Pilekia* apparently do not have the thoracic spines in the articulating line and as the spines are unlikely to be a primitive character it seems reasonable to speculate that both *P. apollo* and *V. holmesorum* evolved from some forms without thoracic spines. I suggest that *Victorisipina* may have arisen from *P. apollo* or at least some species of *Pilekia* with thoracic spines in the articulating line and that *Parapilekia* arose from some different species of *Pilekia* without thoracic spines. The features common to *Victorisipina* and *Parapilekia* are therefore probably homeomorphous.

Victorisipina holmesorum sp. nov.

Plate 29, figures 1-13; plate 30, figures 1, 3-5

Etymology: The specific epithet is for Frank and Enid Holmes who donated several important specimens of this taxon.

Material: Holotype NMVP74446, paratypes NMVP74445, 74447-74459, 74461, 74462 and a further 20 to 30 fragmentary specimens of cranidia and pygidia from NMVPL184.

Diagnosis: As for genus.

Description: Glabella subrectangular, with frontal lobe and occipital ring narrower than rest, with transverse anterior margin and rounded anterolateral corners, with three pairs of lateral glabellar furrows, having axial ridge between evenly sloping sections and sharp narrow drop into axial furrow in anterior profile; glabellar furrows straight, slit-like, at low angle to transverse line, parallel to each other; furrow 1p not reaching occipital furrow; furrow 3p with distinct anterior fork extending a short distance forward from the abaxial half of the furrow; occipital furrow well-impressed, arching very subtly forward over the axis and at the axial furrow; occipital ring slightly elongate medially, convex in lateral profile; axial furrow well-impressed, U-shaped in section, straight and exsagittal except for adaxial curve posteriorly to the occipital ring and anteriorly

where a sharp turn adaxially occurs just behind the junction with the eye ridge before the furrow becomes exsagittal again; preglabellar furrow well-impressed, shorter than axial furrow is laterally, of uniform length; anterior border very short medially, becoming more elongate laterally, strongly convex, with ornament of extremely fine pustules medially being replaced laterally by the general coarse tubercles; eye ridge convex in section, narrow, meeting axial furrow at level of anterior of glabellar lobe 3p, continuing laterally directly into palpebral lobe; palpebral lobe slightly wider than eye ridge in section, gently arcuate, curving posteriorly from line of eye ridge, defined by well-impressed palpebral furrow continuing behind eye ridge to axial furrow and continuing behind palpebral lobe onto librigena beneath eye socle; facial suture running in exsagittal line forward of palpebral lobe for short distance then curving adaxially across border, sigmoidal behind palpebral lobe, with wide middle limb, meeting posterior margin in right angle; fixigena large, wide, almost horizontal adaxially but strongly downsloping lateral to articulating line through posterior of palpebral lobe, covered with strongly interconnecting maze of caeca separated by distinct pits, with sparse coarse tubercles surmounting caeca; posterior border furrow well-impressed, of uniform length throughout; posterior border short, becoming elongate laterally, without ornament, with strong spine at least as long as cranium issuing from top of the border in the articulating line and rising up almost vertically in posterolateral direction. Librigena long and narrow, virtually flat, with ornament of caecal ridges and intervening pits as on fixigena, with coarse tubercles on caeca and on adaxial part of border, with fine pustulose ornament towards margin; eye socle low but distinct, border furrow deep, with steep almost vertical slope up to border but much gentler slope to genal field; border flat adaxially rolling over margin, continuing unchanged around spineless rounded genal angle. Surface of cranium except for furrows or unless stated otherwise covered with widely separated coarse tubercles.

Thorax of more than 10 segments; articulating halfring and axial ring of approxi-

mately same length; pleura with short sharp pleural furrow running in midlength as far as articulating line, with long almost vertical spine arising from posterior pleural band at the articulating line; free pleura downturned, with spinose tip, with short inclined articulating facet; line of coarse tubercles on axial ring and pleural bands.

Pygidium transverse; axis of four rings and short subtriangular terminus reaching posterior margin and enclosed laterally by bases of fourth marginal spines, with short pseudoarticulating halfring on first ring, tapering posteriorly, with convex lateral margins, convex in anterior profile but not standing too far above pleural field; pleural field crossed by two pleural and three interpleural furrows, with anterior pleural band of first two segments greatly reduced, with posterior pleural bands extended into four pairs of marginal spines directed posteriorly; marginal spines round in section, becoming progressively shorter posteriorly; axial rings and pleural bands with rows of coarse tubercular ornament.

Pilekia Barton, 1915

Type species (by original designation): *Cheirurus apollo* Billings, 1860.

Pilekia sp.

Plate 32, figures 2-6

Material: Three crania NMVP74476, 71216, 71217 and two pygidia NMVP71215, 71218 from NMVPL184.

Remarks: The glabella tapers forward strongly with convex lateral margins, three pairs of wide short lateral furrows and the 1p lobe quite bulbous. The anterior border is short, convex and separated from the glabella only by a short deep border furrow. The palpebral lobe is slightly expanded distally, curves posteriorly so that the interocular cheek is narrower than in most species. The fixigena behind the palpebral lobe is quite large and bears a strong genal spine on the posterior border some distance behind the facial suture. The pygidium bears four pairs of large slightly curved marginal spines directed posteriorly. Anterior pleural bands of the first two segments are not markedly reduced as they are in third and fourth segments. The axis has

four rings and a terminus; termination of the latter is not seen on available material.

No particularly distinctive features present themselves on this material that is too poorly preserved for formal description. *Pilekia* sp. nov. (Jell & Stait, 1985) from Tasmania is distinguished by its non-uniform pygidial marginal spines but distinctions from *Pilekia apollo* and *P. trio* Hintze, 1953 are not at all easy on available material and in the absence of knowledge of a pygidium for the latter species. Reduction of the anterior pleural band of the third pygidial rib on the Victorian material may separate it from *P. apollo*. This material records the presence of the genus in Victoria and, when better material becomes available, will probably form the basis of a new species.

Tessalacauda Ross, 1951

Type species (by original designation): *Tessalacauda depressa* Ross, 1951.

Tessalacauda ? sp.

Plate 32, figure 1

Material: One incomplete and distorted internal cranidial mould, NMVP74475 from NMVPL184.

Remarks: This single fragment resembles *Tessalacauda* in the parallel-sided to slightly anteriorly expanding glabella, with short lateral glabellar furrows, very large fixigena, course of the posterior border furrow, and cheek ornament. Although these features are not sufficiently distinctive to make a positive identification they do suggest this genus above all others described to date. The only feature which does not fit with *T. depressa* is the position of the palpebral lobe closer to the glabella but that would be a specific taxobase if in combination with other distinctive features. For the present this specimen suggests the occurrence of the genus in Australia but confirmation of that distribution must await better material.

Family PLIOMERIDAE Raymond, 1913

Protopliomerops Kobayashi, 1934

Type species (by original designation): *Protopliomerops seisonensis* Kobayashi, 1934.

Protopliomerops lindneri sp. nov.

Plate 30, figure 2; plate 32, figures 7-10; plate

33, figures 1-4; text-fig. 2

Etymology: The species is named for Mr A. W. Lindner who first recorded the occurrence of these trilobite fossils in 1953.

Material: Holotype NMVP71225, paratypes NMVP71219-71224, 71227, 74460 from NMVPL184.

Diagnosis: Member of *Protopliomerops* with palpebral lobes close to glabella, with 3p glabellar furrow reaching axial furrow at anterolateral corner of glabella at same level as eye ridge, with pointed genal angle (not spinose). Pygidium with axis of four rings and small triangular terminus not reaching posterior margin, with short anterior pleural band on first segment but only posterior band present on subsequent segments, with pleurae extended into four pairs of strong marginal spines, with marginal spines well separated and anterior ones curving back but posterior ones exsagittal.

Description: Cranidium semicircular, of moderate convexity, with axis standing well above pleurae; glabella with straight and parallel to very gently converging sides, with broadly rounded anterior, with three pairs of wide, short well-impressed lateral furrows; occipital furrow deep, with U-shaped section, becoming elongate and with anterior margin curving forward over axis, shortest and deepest in narrow lateral part curving forward to axial furrow; occipital ring long, with flat lateral profile, slightly elongate medially, continuing across axial furrow as very low ridge into posteroproximal corner of fixigena; lateral glabellar furrow 1p at greater angle to transverse line than 2p or 3p, turning sharply back and shallowing at adaxial end to reach occipital furrow; furrows 2p and 3p with same posterior turn in shallowing adaxial end, 3p at anterolateral corner of glabella; anterior border very short and convex anteriorly, merely a rim on glabellar anterior, more elongate and then of constant cross-section as far as genal angle; palpebral lobe large, bean-shaped, oriented almost exsagittally close to axial furrow, elevated almost to height of glabella, with very narrow eye ridge connecting it to axial furrow, situated lateral to 2p and 3p glabellar furrows; posterior cephalic limb wide

and long, punctate with fine pustules on ridges surrounding pits, with well-impressed transverse border furrow isolating convex border becoming flatter and longer laterally; genal angle pointed and slightly drawn out but not truly spinose; facial suture proparian, converging forward from palpebral lobe to run across border very obliquely in slight furrow just lateral to axial furrow, transverse behind palpebral lobe but convex forward near border furrow then curving back across border but still well in front of genal angle. Librigena with vertical visual surface, low steep eye socle, sloping narrow genal field ornamented as on fixigena, with convex pustulose border almost as wide as genal field.

Pygidium subtriangular, with four pairs of marginal spines; axis of four segments and very small triangular terminus not reaching margin, rings becoming shorter and narrower posteriorly, of inverted conical shape with pointed tip, with transaxial furrows longer medially than laterally; pleural areas crossed by deep interpleural furrows and ribs extending into marginal spines, with short anterior border and short border furrow low on anterior of first rib; anterior spines curving posteriorly beyond edge of pygidium but posterior ones virtually exsagittal, full extent of spines not known; doublure narrow, becoming longer posteromedially, smooth and inclined up away from the margin; marginal spines arising from dorsal surface of pygidium not interfering with doublure; pygidial surface finely pustulose.

Discussion: *Protopliomerops lindneri* is distinguished most easily by its large palpebral lobes situated almost exsagittally close to the axial furrow, by its anteriorly rounded glabella, sigmoidal 1p glabellar furrow, by its 4 pairs of pygidial spines and by the fourth pair of spines enclosing the axial terminus. It most closely resembles *P. quattuor* Hintze, 1953 from the late Tremadoc of western Utah but differs in ornament on cheeks, glabellar shape, length of palpebral lobe, shape of 1p glabellar furrow, more transverse pygidium and smaller axial terminus. *Rossaspis pliomeris* Demeter, 1973 has some features in common with *P. lindneri* namely the pitted ornament of the cheeks, shape of the 1p glabellar furrow, glabellar

shape and transverse pygidium with 4 pairs of spines and small enclosed axial terminus. However, the species from Utah has distinctly different palpebral lobes, genal spine, and much finer and shallower furrows throughout. Nevertheless, this may be the most similar species so far described.

Unassigned hypostomes

Plate 33, figures 5-16

Remarks: A variety of hypostomes occurred in this fauna that were not found in direct association with any cranidia and could not be assigned to any species with confidence. Of the illustrated hypostomes five (Pl. 33, figs 5-9) appear to belong to one species which may be *Pseudokainella diggerensis* as the type of ornament is known in that family and the size range available seems to fit also. One type of hypostome (Pl. 33, fig. 11) reaches very large size and may belong to the largest species—*Leiostiegium douglasi*. Of the others Pl. 33 figs 13 and 16 each represent different species but those in figures 10, 12, 14 and 15 may belong to a single species that could be one of the pilekiids by comparison with that of *Tessalacauda* (see Ross, 1951, pl. 31, fig. 30).

References

- BARTON, D. C., 1915. A revision of the Cheirurinae, with notes on their evolution. *Wash. Univ. Stud. scient. Ser. 3*: 101-152.
- BEAVIS, F. C., 1976. Ordovician. *Spec. Publ. Geol. Soc. Aust.* 5: 25-44.
- BENEDETTO, J. L., 1977. Una nueva fauna de trilobites Tremadocianos de la provincia de Jujuy (Sierra de Cajas), Argentina. *Ameghiniana*. 14: 186-214.
- BERG, R. R. & ROSS, R. J., 1959. Trilobites from the Peerless and Manitou Formations, Colorado. *J. Paleont.* 33: 106-119.
- BILLINGS, E., 1860. On some new species of fossils from the limestones near Point Levi opposite Quebec. *Can. Naturalist* 5: 301-324.
- BILLINGS, E., 1865. Palaeozoic fossils, volume 1. Containing descriptions and figures of new or little known species of organic remains from Silurian rocks. 1861-1865. *Geol. Surv. Canada* 426 pp.
- BRIDGE, J., 1930. Geology of the Eminence and Cardareva Quadrangles. *Missouri Bur. Geol. Mines* 24: 212-222.
- CHATTERTON, B. D. E., 1980. Ontogenetic studies of Middle Ordovician trilobites from the Esbataottine Formation, Mackenzie Mountains, Canada. *Palaeontographica A* 171: 1-74.
- CHEN, JU-YUAN, TEICHERT, C., ZHOU, ZHI-YI, LIN YAO-KUN, WANG, ZHI-HAO & XU, JUN-TAO, 1983. Faunal sequence across the Cambrian-Ordovician boundary in northern China and its international correlation. *Geol. et Palaeontol.* 17: 1-15.

- CHUGAEVA, M. N. & APOLLONOV, M. K., 1982. The Cambrian-Ordovician boundary in the Batyrbaissai section, Malyy Karatau Range, Kazakhstan, USSR. In *The Cambrian-Ordovician boundary: sections, fossil distributions, and correlations*. M. G. Bassett & W. T. Dean, eds, National Museum of Wales, Geological Series, No. 3, Cardiff, 77-85.
- COOPER, R. A., 1979. Sequence and correlation of Tremadoc graptolite assemblages. *Alcheringa* 3: 7-19.
- COOPER, R. A. & STEWART, I., 1979. The tremadoc graptolite sequence of Lancefield, Victoria. *Palaeontology* 22: 767-797.
- DEMETER, E. J., 1973. Lower Ordovician pliomeric trilobites from western Utah. *Geology Stud. Brigham Young Univ.* 20(4): 37-65.
- DRUCE, E. C., SHERGOLD, J. H. & RADKE, B. M., 1982. A reassessment of the Cambrian-Ordovician boundary section at Black Mountain, western Queensland, Australia. In *The Cambrian-Ordovician boundary: sections, fossil distributions, and correlations*. M. G. Bassett & W. T. Dean, eds, National Museum of Wales, Geological Series, No. 3, Cardiff, 193-209.
- FORTEY, R. A., 1980. The Ordovician trilobites of Spitsbergen 3. Remaining trilobites of the Valhallfonna Formation. *Skr. norsk Polarinst.* 171: 1-163.
- FORTEY, R. A., LANDING, E. & SKEVINGTON, D., 1982. Cambrian-Ordovician boundary sections in the Cow Head Group, western Newfoundland. In *The Cambrian-Ordovician boundary: sections, fossil distributions, and correlations*. M. G. Bassett & W. T. Dean, eds, National Museum of Wales, Geological Series, No. 3, Cardiff, 95-129.
- HARRINGTON, H. J., 1937. On some Ordovician fossils from northern Argentina. *Geol. Mag.* 74: 97-124.
- HARRINGTON, H. J., 1938. Sobre las faunas del Ordoviciano inferior del norte Argentico. *Rev. Museo La Plata, n.s., sec. paleont.* 1: 109-289.
- HARRINGTON, H. J. & LEANZA, A. F., 1957. Ordovician trilobites of Argentina. *Spec. Publ. Univ. Kans. Dept. Geol.* 1: 1-276.
- HARRINGTON, H. J., MOORE, R. C. & STUBBIFIELD, C. J., 1959. Morphological terms applied to Trilobita. In *Treatise on Invertebrate Paleontology, Part 0, Arthropoda 1*, R. C. Moore, ed., Geol. Soc. Amer. & Univ. Kansas Press, Lawrence, Kansas, 117-126.
- HARRINGTON, H. J., et al., 1959. Systematic descriptions. In *Treatise on Invertebrate Paleontology, Part 0, Arthropoda 1*, R. C. Moore, ed., Geol. Soc. Amer. & Univ. Kansas Press, Lawrence, Kansas, 170-540.
- HINTZE, L. J., 1953. Lower Ordovician trilobites from western Utah and eastern Nevada. *Bull. Utah geol. Miner. Surv.* 48: 1-249.
- HOWELL, B. F., 1935. Cambrian and Ordovician trilobites from Herault, southern France. *J. Paleont.* 9: 222-238.
- JELL, P. A. & STAIT, B., 1985. Tremadoc trilobites from the Florentine Valley Formation, Tim Shea area, Tasmania. *Mem. natn. Mus. Vict.* (this volume)
- JONES, P. J., SHERGOLD, J. H. & DRUCE, E. C., 1971. Late Cambrian and Early Ordovician stages in western Queensland. *J. geol. Soc. Aust.* 18: 1-32.
- KENNEDY, D. J., 1971. Ordovician conodont faunas in southern Australia. ANZAAS 43rd Congress, Section C Abstracts, Brisbane, 43.
- KOBAYASHI, T., 1931. Studies on the stratigraphy and palaeontology of the Cambro-Ordovician formations of the Hua-lien-chai and Niu-hsin-tai, south Manchuria. *Jap. J. Geol. Geogr.* 8: 131-189.
- KOBAYASHI, T., 1934. The Cambro-Ordovician formations and faunas of South Chosen. *Palaeontology. Part 2. Lower Ordovician faunas. J. Fac. Sci. Tokyo Univ., ser. 2, 3: 521-585.*
- KOBAYASHI, T., 1937. The Cambro-Ordovician shelly faunas of South America. *J. Fac. Sci. Tokyo Univ., ser. 2, 4: 369-522.*
- KOBAYASHI, T., 1939. On the agnostids (Part 1). *J. Fac. Sci. Tokyo Univ., ser. 2, 5: 69-198.*
- KOBAYASHI, T., 1955. The Ordovician fossils of the McKay Group in British Columbia, western Canada, with a note on the Early Ordovician palaeogeography. *J. Fac. Sci. Tokyo Univ., ser. 2, 9: 355-493.*
- KUO, HUNG-CHUN, DUAN JI-YE & AN, SU-LAN, 1982. Cambrian-Ordovician boundary in the north China platform with descriptions of trilobites. Paper for the Fourth International Symposium on the Ordovician System, 1982, Dept. of Geology, Changchun College of Geology, Changchun, 1-31, 3 pls.
- LAKI, P., 1906. Monograph of the British Cambrian trilobites, part 1. *Palaeontogr. Soc. Lond. Mon.* 60 (1906): 1-28.
- LANE, P. D., 1971. *British Cheiruridae (Trilobita)*. Palaeontographical Society Monograph, London, 95 p.
- LINDNER, A. W., 1953. The geology of the coastline of Waratah Bay between Walkerville and Cape Liptrap. *Proc. R. Soc. Vict.* 67: 77-92.
- LINOGOR, K. A., 1977. Biostratigraphy and trilobites of the Upper Cambrian and Tremadocian of Malay Karatau (southern Kazakhstan). *Trudy Inst. Geol. i Geofiz.* 313: 197-264.
- LU, YAN-HAO, CHANG, W. T., CHU, CHAO-LING, CHEN, YI-YUAN & HSIANG, L. W., 1965. *Fossils of China. Chinese Trilobites*. Science Press, Peking, 766 p.
- LUDVIGSEN, R., 1982a. The Cambrian-Ordovician boundary in the western District of Mackenzie, Canada. In *The Cambrian-Ordovician boundary: sections, fossil distributions, and correlations*. M. G. Bassett & W. T. Dean, eds, National Museum of Wales, Geological Series, No. 3, Cardiff, 141-153.
- LUDVIGSEN, R., 1982b. Upper Cambrian and Lower Ordovician trilobite biostratigraphy of the Rabbitkettle Formation, western District of Mackenzie. *Contr. Life Sci. R. Ontario Mus.* 134: 1-188.
- MOBERG, J. C. & SEGERBERG, C. O., 1906. Bidrag till kannedomen om Ceratopygeregionen med sarskild hansyn till des utveckling i Fagelsangstrakten. *Lunds Univ. Arsskr., N.F., Afd. 2, 2: 1-113.*
- OPIK, A. A., 1967. The Mindyallan fauna of northwestern Queensland. *Bur. Miner. Resour. Geol. Geophys. Aust. Bull.* 74: 1-404 and 1-166.
- OWENS, R. M., FORTEY, R. A., COPE, J. C. W., RUSHFON, A. W. A. & BASSETT, M. G., 1982. Tremadoc faunas from the Carmarthen district, South Wales. *Geol. Mag.* 119: 1-38.
- PAIMER, A. R., 1968. Cambrian trilobites of east-central Alaska. *Prof. Pap. U.S. geol. Surv.* 559B: 1-115.
- PENG, SHAN-CHI, 1983. Cambrian-Ordovician boundary in the Cili-Taouyan border area, northwestern Hunan. In *Papers for the Symposium on the Cambrian-Ordovician and Ordovician-Silurian boundaries*, Nanjing Inst. Geol. & Palaeo., Academia Sinica, Nanjing, 44-52.
- RASETTI, F., 1944. Upper Cambrian trilobites from the Levis Conglomerate. *J. Paleont.* 18: 229-258.
- RASLITI, F., 1952. Cephalic sutures in the Upper Cambrian trilobite *Entomaspis*. *J. Paleont.* 26: 797-802.
- RAYMOND, P. E., 1905. Notes on the names *Amphion*, *Harpina* and *Platymetopus*. *Am. J. Sci.* 4: 377-378.

- RAYMOND, P. E., 1913. A revision of the species which have been referred to the genus *Bathyrurus*. *Bull. Victoria meml Mus.* 1: 51-80.
- RAYMOND, P. E., 1924. New Upper Cambrian and Lower Ordovician trilobites from Vermont. *Proc. Boston Soc. Nat. Hist.* 37: 389-466.
- RAYMOND, P. E., 1937. Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont. *Bull. geol. Soc. Amer.* 48: 1079-1146.
- ROBISON, R. A. & PANTOJA-ALOR, J., 1968. Tremadocian trilobites from the Nochixtlan region, Oaxaca, Mexico. *J. Paleont.* 42: 767-800.
- ROSS, R. J., 1951. Stratigraphy of the Garden City Formation in northeastern Utah, and its trilobite faunas. *Bull. Peabody Mus. nat. Hist.* 6: 1-161.
- ROSS, R. J. & SHAW, F. C., 1972. Distribution of the Middle Ordovician Copenhagen Formation and its trilobites in Nevada. *Prof. Pap. U.S. geol. Surv.* 749: 1-33.
- SHERGOLD, J. H., 1971. Late Upper Cambrian trilobites from the Gola Beds, western Queensland. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 112: 1-89.
- SHERGOLD, J. H., 1975. Late Cambrian and Early Ordovician trilobites from the Burke River Structural Belt, western Queensland, Australia. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* 153: 1-251.
- SHERGOLD, J. H., 1977. Classification of the trilobite *Pseudagnostus*. *Palaeontology* 20: 69-100.
- SHERGOLD, J. H., COOPER, R. A., DURCE, E. C. & WEBBY, B. D., 1982. Synopsis of selected sections at the Cambrian-Ordovician boundary in Australia, New Zealand, and Antarctica. In *The Cambrian-Ordovician boundary: sections, fossil distributions, and correlations*. M. G. Bassett & W. T. Dean, eds, National Museum of Wales, Geological Series, No. 3, Cardiff, 211-227.
- SINGLETON, O. P., 1967. South Gippsland. *Excursions Handbook, 39th Congress ANZAAS, Sect. C*: 15-24.
- TAYLOR, M. E., 1976. Indigenous and redeposited trilobites from Late Cambrian basinal environments of central Nevada. *J. Paleont.* 50: 668-700.
- TROLDSSON, G. T., 1937. On the Cambro-Ordovician faunas of western Quruq Tagh, eastern Tien-Shan. *Palaeont. sin., ser. B*: 2: 1-74.
- WATCOTT, C. D., 1925. Cambrian and Ozarkian trilobites. *Smithson. misc. Collns* 75: 61-146.
- WEBBY, B. D., VANDENBERG, A. H. M., COOPER, R. A., BANKS, M. R., BURRETT, C. F., HENDERSON, R. A., CLARKSON, P. D., HUGHES, C., LAURIE, J., STAIT, B., THOMSON, M. R. A., & WEBERS, G., 1981. Ordovician System in Australia, New Zealand and Antarctica. *IUGS Publ.* 6: 1-64.
- WHITTINGTON, H. B., 1961. Middle Ordovician Plomeridae (Trilobita) from Nevada, New York, Quebec, Newfoundland. *J. Paleont.* 35: 911-922.
- WHITWORTH, P. H., 1969. The Tremadoc trilobite *Pseudokainella impar* (Salter). *Palaeontology* 12: 406-413.
- ZHOU, ZHI-YI & ZHANG JIN-LIN, 1978. Cambrian-Ordovician boundary of Tangshan area with descriptions of the related trilobite fauna. *Acta. Palaeontol. Sinica* 17: 1-26.
- ZHOU, ZHI-YI & ZHANG, JIN-LIN, 1983. Uppermost Cambrian and lowest Ordovician trilobites of north and northeast China. In *Papers for the Symposium on the Cambrian-Ordovician and Ordovician-Silurian boundaries*, Nanjing Inst. Geol. & Palaeo., Academia Sinica, Nanjing, 25-30.

Explanation of Plates

PLATE 19

Figs 1-5. *Neoagnostus eckardti* sp. nov.

- Figure 1. Latex cast of slightly incomplete external mould of pygidium in dorsal (A) and posterior (B) views showing posteromedian node, zonate posterior border and degree of convexity, NMVP74319, $\times 10$.
- Figure 2. Exfoliated internal mould of damaged cranidium, NMVP74320, $\times 10$.
- Figure 3. Partially exfoliated cranidium, NMVP74321, $\times 10$.
- Figure 4. Exfoliated pygidium showing axial nodes and transaxial furrows, NMVP74322, $\times 10$.
- Figure 5. Internal mould of HOLOTYPE cranidium showing preglabellar furrow, glabellar segmentation, and glabellar node, NMVP74323, $\times 10.5$.

Figs 6-14. *Micragnostus hoeki* Kobayashi, 1939

- Figure 6. Internal mould of cranidium showing glabellar node well back from transglabellar furrow, NMVP74324, $\times 7$.
- Figure 7. Damaged internal mould of complete specimen showing association of head and tail, NMVP74325, $\times 5$.
- Figure 8. Exfoliated latex cast from imperfect external mould showing faint preglabellar median furrow, faint caecal impressions on right side and straight transglabellar furrow, NMVP74326, $\times 10$.
- Figure 9. Partially exfoliated latex cast from imperfect slightly distorted external mould of cranidium showing glabellar node and lateral lobes on posterior glabellar lobes, NMVP74327, $\times 8$.
- Figure 10. Partially exfoliated latex cast from incomplete external mould of pygidium showing exsagittal lobation of second axial ring, NMVP74328, $\times 7$.
- Figure 11. Pygidium showing external surface in posterior (A) and dorsal (B) views marginal spines, large axial node, general convexity, and poorly defined axial furrow at rear of axis well in front of and above border furrow, NMVP74329, $\times 10$.
- Figure 12. Slightly distorted internal mould of pygidium showing marginal spines, and extent of axis, NMVP74330, $\times 10$.
- Figure 13. Exfoliated latex cast from slightly distorted and incomplete pygidium showing lobation of axis both transversely and exsagittally, NMVP 74331, $\times 7$ (faint parallel lines on surface are

result of ammonium chloride forming in pattern probably induced by finger prints on the latex before whitening—they do not reflect a feature of the trilobite).

Figure 14. Latex cast of partially exfoliated slightly compressed (in transverse direction) pygidium showing narrow axial node, long border and anteriorly placed marginal spines, NMVP 74332, $\times 8$.

Figs 15-19. *Shumardia erquensis* Kobayashi, 1937

Figure 15. Internal mould of slightly distorted cranium, NMVP74333, $\times 15$.

Figure 16. Internal mould of slightly damaged cranium, NMVP74334, $\times 15$.

Figure 17. Latex cast from imperfect external mould of cranium, NMVP74335, $\times 15$.

Figure 18. Internal mould of slightly damaged cranium, NMVP74336, $\times 13$.

Figure 19. Latex cast from imperfect external mould of cranium in anterior (A) lateral oblique (B) and dorsal (C) views showing fine border as a marginal rim, NMVP74337, $\times 15$.

PLATE 20

Figs 1-3. *Parahystericurus* sp. cf. *P. fraudator* Ross, 1951

Figure 1. Fragmentary internal mould of cranium showing short, wide, forward-placed palpebral lobes, NMVP74338, $\times 6$.

Figure 2. Internal mould of cranium showing glabellar furrows, preglabellar connection to border furrow, long posterior cephalic limb and anteriorly-converging facial suture, NMVP 74339, $\times 6$.

Figure 3. Latex cast of fragmentary cranium in anterior (A) and dorsal (B) views showing ornament, furrows, border, and palpebral lobe in anterior of cranium, NMVP74340, $\times 6$.

Figs 4-8. *Hystericuridae* gen. et sp. nov.

Figure 4. Latex cast from slightly incomplete external mould in dorsal (A) and anterior (B) views showing fossulae, anterior border shape, glabellar furrows, and long narrow posteriorly-situated palpebral lobe, NMVP74341, $\times 7$.

Figure 5. Latex cast from incomplete distorted (dextral strain) external mould of cranium, NMVP 74342, $\times 7$.

Figure 6. Internal mould of distorted (laterally compressed) cranium, NMVP74343, $\times 6$.

Figure 7. Largely exfoliated latex cast of small cranium, NMVP74344, $\times 8$.

Figure 8. Latex cast from imperfect distorted (fore-shortened) cranium showing course of occipital and axial furrows, NMVP74345, $\times 6$.

Figs 9-12. *Natmus tuberus* gen. et sp. nov.

Figure 9. Incomplete latex cast (A) and internal mould (B) of damaged cranium showing anterior border furrow pits, preglabellar boss, high extended posterior palpebral lobes, and markedly different expression of the ornament on external and internal surfaces of exoskeleton, NMVP74346, $\times 9$.

Figure 10. Latex cast from fragmentary external mould of cranium, NMVP74347, $\times 13$.

Figure 11. Latex cast from damaged slightly distorted external mould showing the fixigenal spine, NMVP74348, $\times 10$.

Figure 12. Latex cast (A) and internal mould (B) of damaged holotype, cranium showing occipital node, fixigenal spine, glabellar furrows and large smooth area posteroproximally on fixed cheek, NMVP74349, $\times 7$.

PLATE 21

Natmus victus gen. et sp. nov.

Figure 1. Latex cast from small damaged external mould of cranium, NMVP74350, $\times 8$.

Figure 2. Latex cast from incomplete external mould of cranium in dorsal (A) and anterolateral oblique (B) views showing ornament, NMVP 74351, $\times 6$.

Figure 3. Latex cast from incomplete external mould of holotype cranium in anterior (A) and dorsal (B) views showing elevated palpebral lobes, occipital spine, and glabellar furrows, NMVP74352, $\times 7$.

Figure 4. Latex cast from incomplete external mould of cranium (latex imperfect at occipital spine), NMVP74353, $\times 5$.

Figure 5. Internal mould of damaged cranium, NMVP74354, $\times 8$.

Figure 6. Latex cast from incomplete external mould of cranium, NMVP74355, $\times 7$.

Figure 7. Internal mould of damaged cranium, NMVP74356, $\times 7$.

Figure 8. Latex cast from incomplete external mould of cranium showing wide posterior cephalic limb, NMVP74357, $\times 10$.

Figure 9. Latex cast from fragmentary external mould of cranium showing difference in ornament between glabella and cheeks, NMVP74358, $\times 8$.

Figure 10. Latex cast from slightly incomplete external mould of complete specimen showing at least 16 thoracic segments each with median node, and becoming narrower and curved to the posterior (also indicating that the pygidium was tiny), NMVP74359, $\times 7$.

Figure 11. Damaged internal mould of complete specimen showing mould of long genal spine, NMVP74360, $\times 2.5$.

Figure 12. Latex cast from incomplete external mould of librigena in oblique lateral view showing eye surface, eye socle, ornament, discontinuous border furrow, and genal spine, NMVP74361, $\times 10$.

Figure 13. Latex cast from imperfect external mould of librigena showing long genal spine, NMVP74362, $\times 6$.

Figure 14. Internal mould of librigena, NMVP74363, $\times 8$.

Figure 15. Internal mould of damaged cranium in dorsal (A) and anterolateral oblique (B) views showing short wide posterior cephalic limb and glabellar furrows, NMVP74364, $\times 6$.

PLATE 22

Figs 1-10. *Leioestegium douglasi* Harrington, 1937

Figure 1. Almost completely exfoliated latex cast from damaged slightly distorted (sinistral strain) cranium showing glabellar furrows, and caecal development in anterior border and forward of eye ridge, NMVP74365, $\times 3$.

Figure 2. Latex cast from imperfect external mould of librigena showing perforated exoskeleton, eye socle, marginal terrace lines extending down genal spine, and course of facial suture to margin, NMVP74366, $\times 2.5$.

Figure 3. Partly exfoliated latex cast from imperfect external mould of librigena showing course of facial suture across doublure anteriorly, posteriorly shallowing border furrow and long genal spine, NMVP15629, $\times 2$.

Figure 4. Partially exfoliated latex cast from imperfect external mould of cranium showing casts of pits in inner surface of exoskeleton, NMVP74367, $\times 4$.

Figure 5. Latex cast from external mould of cranium showing palpebral lobe, and posterolateral limb, NMVP74368, $\times 5$.

Figure 6. Latex cast from incomplete slightly imperfect external mould of cranium in anterolateral (A) and dorsal (B) views, NMVP74369, $\times 4$.

Figure 7. Latex cast from incomplete external mould of pygidium, NMVP74370, $\times 3$.

Figure 8. Latex cast from incomplete external mould of pygidium, NMVP74371, $\times 2$.

Figure 9. Internal mould of large damaged pygidium and articulated thoracic segments, NMVP74372, $\times 1$.

Figure 10. Latex cast from fragmentary external mould of whole specimen (A) showing the eight thoracic segments and their tips and internal mould (B) of several pleural tips showing extent of doublure ventrally, NMVP74373, $\times 5$.

Figs 11, 12. *Leioestegium* sp. cf. *L. manitouensis* Walcott, 1925

Figure 11. Latex cast from imperfect external mould showing short border, NMVP74374, $\times 4$.

Figure 12. Latex cast from imperfect external mould, NMVP74375, $\times 4$.

PLATE 23

Onchopyge parkerae sp. nov.

Figure 1. Latex cast from imperfect external mould of cranium showing bulging 2p glabellar lobe, 1p furrow, and large palpebral lobe, NMVP74376, $\times 6$.

Figure 2. Latex cast from distorted (sinistral strain and flattening out) incomplete external mould of cranium, NMVP74377, $\times 6$.

Figure 3. Internal mould of damaged cranium, NMVP74378, $\times 5$.

Figure 4. Internal mould of distorted (sinistral strain) cranium, NMVP74379, $\times 7$.

Figure 5. Internal mould of cranium showing posterior cephalic limb, NMVP74380, $\times 5$.

Figure 6. Internal mould of librigena showing extension of doublure forward (suggesting kainelliform suture), NMVP74381, $\times 6$.

Figure 7. Latex cast from imperfect external mould of cranium, NMVP74382, $\times 8$.

Figure 8. Latex cast from imperfect external mould of pygidium, NMVP74383, $\times 8$.

Figure 9. Damaged internal mould of cranium showing glabellar furrows, NMVP74384, $\times 7$.

Figure 10. Mostly exfoliated latex cast from damaged external mould of pygidium, NMVP74385, $\times 5$.

Figure 11. Exfoliated latex cast from incomplete external mould of pygidium, NMVP74386, $\times 6$.

Figure 12. Latex cast from incomplete external mould of librigena, NMVP74387, $\times 8$.

Figure 13. Latex cast from external mould of librigena showing advanced genal spine, border furrow, and terrace lines on border and spine, NMVP74388, $\times 3$.

Figure 14. Latex cast from incomplete external mould of pygidium, NMVP74389, $\times 6$.

Figure 15. External mould of doublure on pygidium, NMVP74390, $\times 4$.

Figure 16. Latex cast from incomplete external mould of part of thorax, NMVP74391, $\times 3$.

PLATE 24

Figs 1-4. *Onychopyge parkerae* sp. nov.

Figure 1. Latex cast from incomplete external mould of holotype pygidium in dorsal (A) and lateral oblique (B) views showing transverse ridges on axis, posteromedial ridge, and ridges on pleural ribs leading down spines, NMVP74392, $\times 6$.

Figure 2. Latex cast from imperfect external mould of pygidium showing long spines, NMVP74393, $\times 7$.

Figure 3. Latex cast from incomplete external mould of pygidium, NMVP74394, $\times 6$.

Figure 4. Latex cast from incomplete external mould of pygidium, NMVP74395, $\times 8$.

Figs 5-14. *Pseudokainella diggerensis* sp. nov.

Figure 5. Latex cast from incomplete external mould of crumpled cranidium showing border furrow pits and diverging anterior parts of suture, NMVP74396, $\times 6$.

Figure 6. Latex cast from incomplete distorted external mould of cranidium, NMVP74397, $\times 5$.

Figure 7. Latex cast from external mould of librigena, NMVP74398, $\times 3$.

Figure 8. Latex cast from incomplete external mould of librigena, NMVP74399, $\times 3$.

Figure 9. Latex cast from incomplete external mould of librigena showing median suture across doublure and row of pits at posterior edge of doublure apparently complementary with those in border furrow dorsally, NMVP74400, $\times 6$.

Figure 10. Latex cast from slightly distorted external mould of small cranidium showing glabellar furrows, NMVP74401, $\times 7$.

Figure 11. Internal mould of large flattened and damaged cranidium, NMVP74402, $\times 3$.

Figure 12. Latex cast from damaged and distorted (sinistral strain) external mould of cranidium, NMVP74403, $\times 5$.

Figure 13. Latex cast from damaged and distorted (anterior border has been forced back under front of glabella so eliminating preglabellar field and greatly increasing convexity of glabella) external mould of cranidium, NMVP74404, $\times 2$.

Figure 14. Latex cast from damaged and distorted external mould of cranidium, NMVP74405, $\times 3.5$.

PLATE 25

Pseudokainella diggerensis sp. nov.

Figure 1. Latex cast from incomplete distorted (fore-shortened) external mould of cranidium in dorsal (A) and anterolateral oblique (B) views, NMVP74406, $\times 4$.

Figure 2. Internal mould of small cranidium, NMVP74407, $\times 5$.

Figure 3. Latex cast from imperfect external mould of juvenile cranidium, NMVP74408, $\times 10$.

Figure 4. Latex cast from incomplete external mould of whole specimen, NMVP74409, $\times 3$.

Figure 5. Latex cast of ventral surface of librigena showing pits at inner edge of doublure anteriorly, forward extension of doublure to medial suture, and terrace lines on doublure, NMVP74410, $\times 5$.

Figure 6. Latex cast from incomplete, damaged external mould of pygidium with five pairs of marginal spines and fine ornament of terrace lines, NMVP74411, $\times 5$.

Figure 7. Latex cast from incomplete external mould of whole specimen, NMVP74412, $\times 2$.

Figure 8. Latex cast from imperfect external mould of pygidium with five pairs of marginal spines, NMVP74413, $\times 6$.

Figure 9. Internal mould of pygidium with four pairs of marginal spines and showing doublure and its ornament, NMVP74414, $\times 3$.

Figure 10. Incomplete internal mould of whole specimen, NMVP74415, $\times 3$.

Figure 11. Latex cast from incomplete and damaged external mould of holotype specimen showing median spine on eighth thoracic segment, and thoracic segment in pygidium just about to move out into thorax, NMVP74416, $\times 2$.

Figure 12. Latex cast from incomplete external mould of pygidium with four pairs of marginal spines, NMVP74417, $\times 6$.

Figure 13. Pygidium with four pairs of marginal spines, NMVP74418, $\times 10$.

PLATE 26

Brachyhipposiderus logimus gen. et sp. nov.

Figure 1. Latex casts of ventral (A) and (B) and dorsal (C) and (D) surfaces from external moulds of holotype cranidium in ventral (A, B), anterolateral oblique (C), and dorsal (D) views, NMVP74419, $\times 4$.

- Figure 2. Latex cast from incomplete external mould of deformed cranidium showing strong ridge and epiborder furrow, NMVP74420, $\times 4$.
- Figure 3. Latex cast from ventral external mould of deformed cranidium showing girder extending to end of prolongation and major caecum extending beyond eye lobe, NMVP74421, $\times 5$.
- Figure 4. Latex cast from deformed incomplete external mould of cranidium in dorsal (A) and anterolateral oblique (B) views, NMVP74422, $\times 4$.
- Figure 5. Latex cast from imperfect external mould of ventral surface of whole specimen showing typical thoracic segments and extent of girder, NMVP74423, $\times 6$.
- Figure 6. Internal mould of slightly deformed cranidium retaining internal mould of caeca in girder and brim on right prolongation, NMVP74424, $\times 4$.
- Figure 7. Latex cast from deformed (sinistral stress) external mould of cranidium, NMVP74425, $\times 4$.
- Figure 8. Latex cast from deformed (sinistral stress) external mould of cranidium, NMVP74426 $\times 4$.

PLATE 27

Figs 1, 3-8. *Australoharpes singletoni* sp. nov.

- Figure 1. Latex cast from slightly deformed external mould of holotype specimen in anterolateral oblique (A) and dorsal (B) views (Note: Mould of rear of cephalon was cleared after latex in (B) had been pulled. Note also way brim drapes over separate exoskeletal fragment at lower right), NMVP74427, $\times 3$.
- Figure 3. Latex cast from incomplete external mould of small cephalon in dorsal (A) and anterolateral oblique (B) views, NMVP74429, $\times 2$.
- Figure 4. Latex cast from incomplete external mould of damaged cephalon in dorsal (A) and lateral oblique (B) views, NMVP74430, $\times 3$.
- Figure 5. Latex cast from incomplete external mould of ventral surface of cephalon showing girder, NMVP74431, $\times 2$.
- Figure 6. Internal mould of damaged cephalon showing long prolongations and spines extending further back, NMVP74432, $\times 2$.
- Figure 7. Latex cast from incomplete external mould of ventral surface of cephalon showing girder ending well before tip of prolongation and without reaching either margin of prolongation, NMVP74433, $\times 3$.
- Figure 8. Latex cast from slightly distorted external mould of thorax and brim (right) and of ventral surface of another brim (left), NMVP74434 and 74435, $\times 4$.

- Figure 2. *Australoharpes expansus* sp. nov. Latex cast from external mould of ventral surface of brim showing girder finishing before tip of prolongation, without reaching either margin and spine on prolongation, NMVP74428; A, $\times 3$; B, $\times 1.5$.

PLATE 28

Australoharpes expansus sp. nov.

- Figure 1. Latex cast from incomplete external mould of ventral surface of cephalon showing girder finishing before tip of prolongation, NMVP74436, $\times 3$.
- Figure 2. Latex cast from incomplete external mould of cephalon showing tiny eye lobes, NMVP74437, $\times 3$.
- Figure 3. Latex cast from incomplete external mould of ventral surface of brim showing median notch (possibly overemphasised by distortion), NMVP74438, $\times 3$.
- Figure 4. Internal mould (A) and latex cast from external mould (B) of holotype cephalon showing small eye lobes and short prolongations on very wide brim, NMVP74439, $\times 4$.
- Figure 5. Latex cast from incomplete external mould of distorted cephalon, NMVP74440, $\times 4$.
- Figure 6. Latex cast from incomplete external mould of distorted cephalon showing small eye lobe, wide brim, and a spine on the short prolongation, NMVP74441, $\times 4$.
- Figure 7. Latex cast from external mould of brim in dorsal (A) and anterolateral oblique (B) views, NMVP74428, $\times 2$.
- Figure 8. Latex cast from incomplete external mould of cephalon showing small eye lobe (with fragment of another individual, inverted on anterior, showing prominent girder), NMVP74442, $\times 3$.
- Figure 9. Latex cast from imperfect external mould of cephalon, NMVP74443, $\times 4$.
- Figure 10. Latex cast from incomplete external mould of distorted cephalon, NMVP74444, $\times 3$.

PLATE 29

Victorisipina holmesorum sp. nov.

- Figure 1. Internal mould of incomplete cranidium in anterior oblique (A) and dorsal (B) views, NMVP74445, $\times 5$.
- Figure 2. Latex cast in dorsal view (A) and internal mould in anterior oblique view (B) of incomplete holotype cranidium showing glabellar furrows and long fixigenal spine, NMVP74446, $\times 2.5$.

Figure 3. Internal mould of damaged cranium in lateral view showing base of fixigenal spine in articulating line and downturned cheek in foreground, NMVP74447, $\times 5$.

Figure 4. Latex cast from incomplete external mould of thoracic segment showing high spine in articulating line, NMVP74448, $\times 5$.

Figure 5. Latex cast from incomplete external mould of thoracic segment in anterior view showing high spine in articulating line and downturned free pleura, NMVP74449, $\times 7$.

Figure 6. Internal mould of thoracic segment in anterior view, NMVP74450, $\times 3.5$.

Figure 7. Internal mould of librigena, NMVP74451, $\times 4.5$.

Figure 8. Imperfect latex cast from external mould of slightly distorted pygidium, NMVP74452, $\times 7$.

Figure 9. Latex cast from external mould of librigena (lower) with anterior to left and cranium of *Natmus victus* sp. nov. (upper), NMVP74453 and 74454, $\times 4$.

Figure 10. Latex cast from incomplete damaged external mould of cranium, NMVP74455, $\times 2.5$.

Figure 11. Latex cast (A) from incomplete external mould and internal mould (B) of pygidium showing ornament, four pairs of spines, reduced anterior pleural bands on first two segments, and shape of axis, NMVP74456, $\times 8$ and $\times 6$ respectively.

Figure 12. Latex cast from incomplete external mould of distorted pygidium, NMVP74457, $\times 9$.

Figure 13. Internal mould of pygidium, NMVP74458, $\times 7$.

PLATE 30

Figs 1, 3, 4. *Victorisipina holmesorum* gen. et sp. nov.

Figure 1. Internal mould of damaged but articulated specimen showing spines on cephalic border, thorax and pygidium, NMVP74459, $\times 3$.

Figure 3. Internal mould of pygidium, NMVP74461, $\times 5$.

Figure 4. Latex cast from distorted incomplete external mould of cranium, NMVP74462, $\times 3.5$.

Figure 2. *Protopliomerops lindneri* sp. nov. Internal mould of pygidium, NMVP74460, $\times 5$.

Figs 5-11. *Landyia elizabethae* gen. et sp. nov.

Figure 5. Latex cast from incomplete damaged external mould of articulated juvenile specimen, NMVP74463, $\times 10$.

Figure 6. Latex cast from incomplete damaged external mould of cranium in anterolateral oblique (A) and dorsal (B) views, NMVP74464, $\times 8$.

Figure 7. Latex cast from incomplete external mould of ventral surface of pygidium showing narrow raised rim around inner edge of doublure, NMVP74465, $\times 10$.

Figure 8. Latex cast from external mould of pygidium, NMVP74466, $\times 5$.

Figure 9. Latex cast from external mould of thorax and pygidium, NMVP74467, $\times 8$.

Figure 10. Latex cast from incomplete external mould of cranium, NMVP74468, $\times 6$.

Figure 11. Latex cast from imperfect external mould of cranium, NMVP74469, $\times 8$.

PLATE 31

Landyia elizabethae gen. et sp. nov.

Figure 1. Latex cast from slightly imperfect and external mould of distorted cranium in dorsal (A) and anterior oblique (B) views, NMVP74470, $\times 6$.

Figure 2. Internal mould of pygidium in posterior (A) and dorsal (B) views, NMVP74471, $\times 6$.

Figure 3. Latex cast from external mould of hypostome in dorsal (A) and lateral oblique (B) views, NMVP74472, $\times 11$.

Figure 4. Latex cast from external mould of librigena, NMVP74473, $\times 10$.

Figure 5. Latex cast from incomplete external mould of whole holotype specimen in lateral (A), anterior oblique (B) and dorsal (C) views; latex cast (D) and external mould (E) of ventral surface of holotype, NMVP74474, $\times 5$.

PLATE 32

Figure 1. *Tessalacauda* ? sp. Internal mould of fragment of cranium, NMVP74475, $\times 2$.

Figs 2-6. *Pilekia* sp.

Figure 2. Internal mould of large damaged cranium in anterior (A) and dorsal (B) views, NMVP74476, $\times 2$.

Figure 3. Internal mould (A) and latex cast (B) from external mould of incomplete pygidium, NMVP71215, $\times 2.5$.

Figure 4. Incomplete internal mould of small cranium, NMVP71216, $\times 4$.

Figure 5. Latex cast from external mould of fragment of left posterior fixigena, NMVP71217, $\times 3$.

Figure 6. Incomplete internal mould of pygidium, NMVP71218, $\times 2$.

Figs 7-10. *Protopliomerops lindneri* sp. nov.

Figure 7. Latex cast from imperfect incomplete external mould of cephalon showing large eye lobe close to axial furrow, glabellar furrows, and librigena in place, NMVP71219, $\times 12$.

Figure 8. Incomplete internal mould of cephalon, NMVP71220, $\times 11$.

Figure 9. Slightly imperfect latex cast from external mould of pygidium showing four pairs of marginal spines, NMVP71221, $\times 5$.

Figure 10. Latex cast from external mould of ventral surface of pygidium showing rim on doublure with steep dorsal slope on inner side and spines arising well above level of doublure, NMVP71222, $\times 4.5$.

PLATE 33

Figs 1-4. *Protopliomerops lindneri* sp. nov.

Figure 1. Latex cast from imperfect external mould of enrolled specimen with pygidium in dorsal (A) and posterior (B) views, NMVP71223, $\times 10$.

Figure 2. Latex cast from fragmentary external mould of cephalon, NMVP71224, $\times 8$.

Figure 3. Internal mould of holotype cephalon in lateral oblique (A) and dorsal (B) views, NMVP71225, $\times 9$.

Figure 4. Incomplete internal mould of cranidium, NMVP71226, $\times 7$.

Figs 5-9. Hypostome unassigned No. 1

Figure 5. Latex cast from external mould of partially exfoliated hypostome, NMVP71227, $\times 10$.

Figs 6, 7, 8. Latex casts from external moulds of hypostomes, NMVP71228, 71229, 71230, $\times 11$, $\times 8$, and $\times 5$, respectively.

Figure 9. External surface of hypostome retaining its calcareous exoskeleton, NMVP71231, $\times 8$.

Figs 10, 12, 14, 15. Unassigned hypostome No. 2

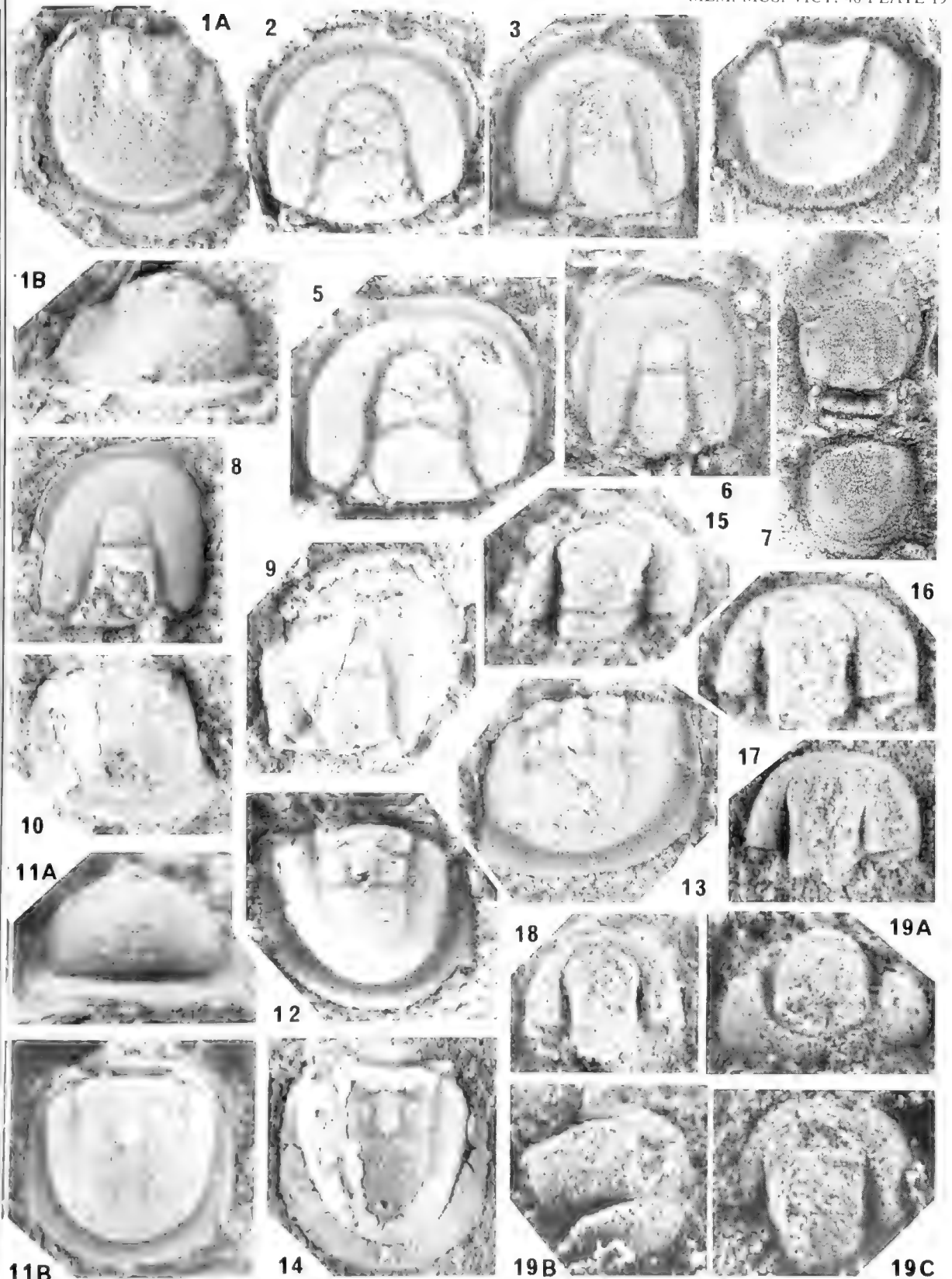
Figs 10, 12, 14. Latex casts from external moulds of hypostomes, NMVP71232, 71234, and 71236, $\times 4$, $\times 4$, and $\times 5$, respectively.

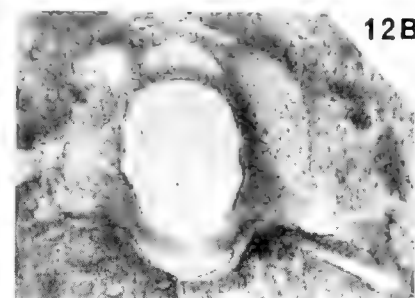
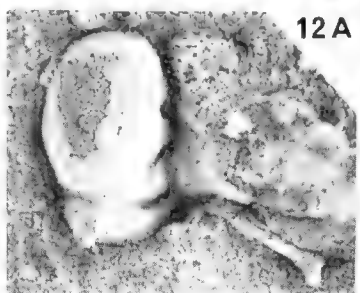
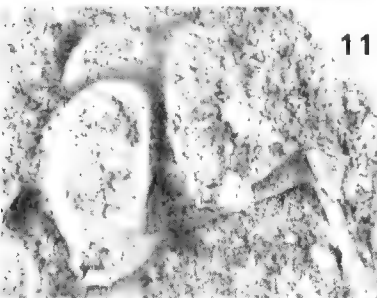
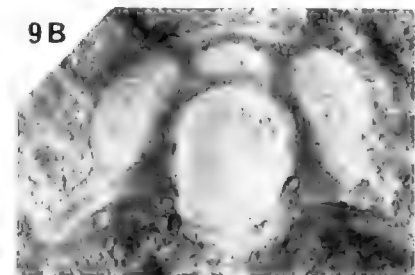
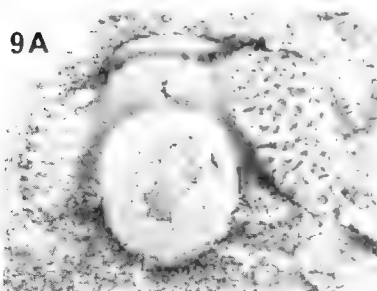
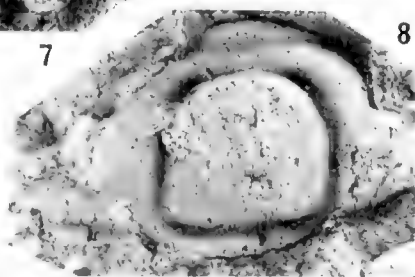
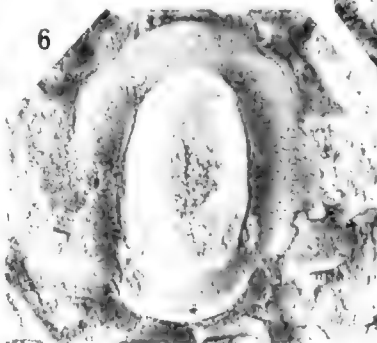
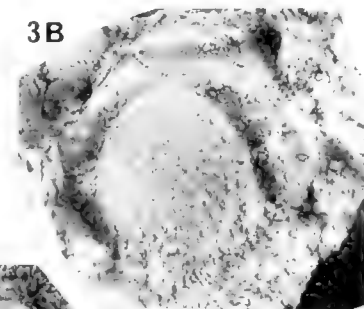
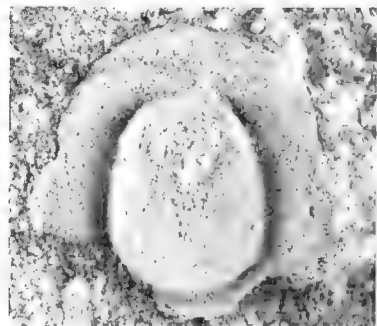
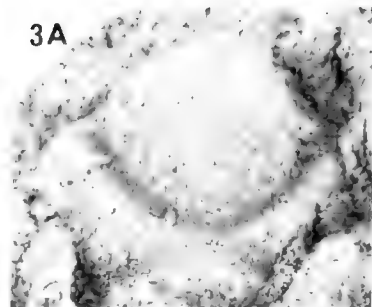
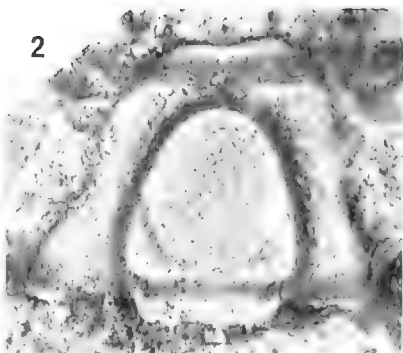
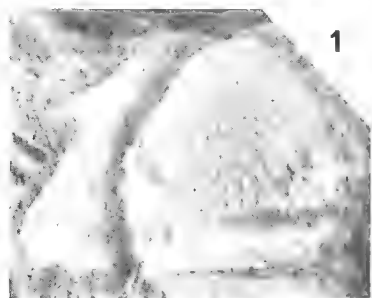
Figure 15. Internal mould of hypostome, NMVP71237, $\times 7$.

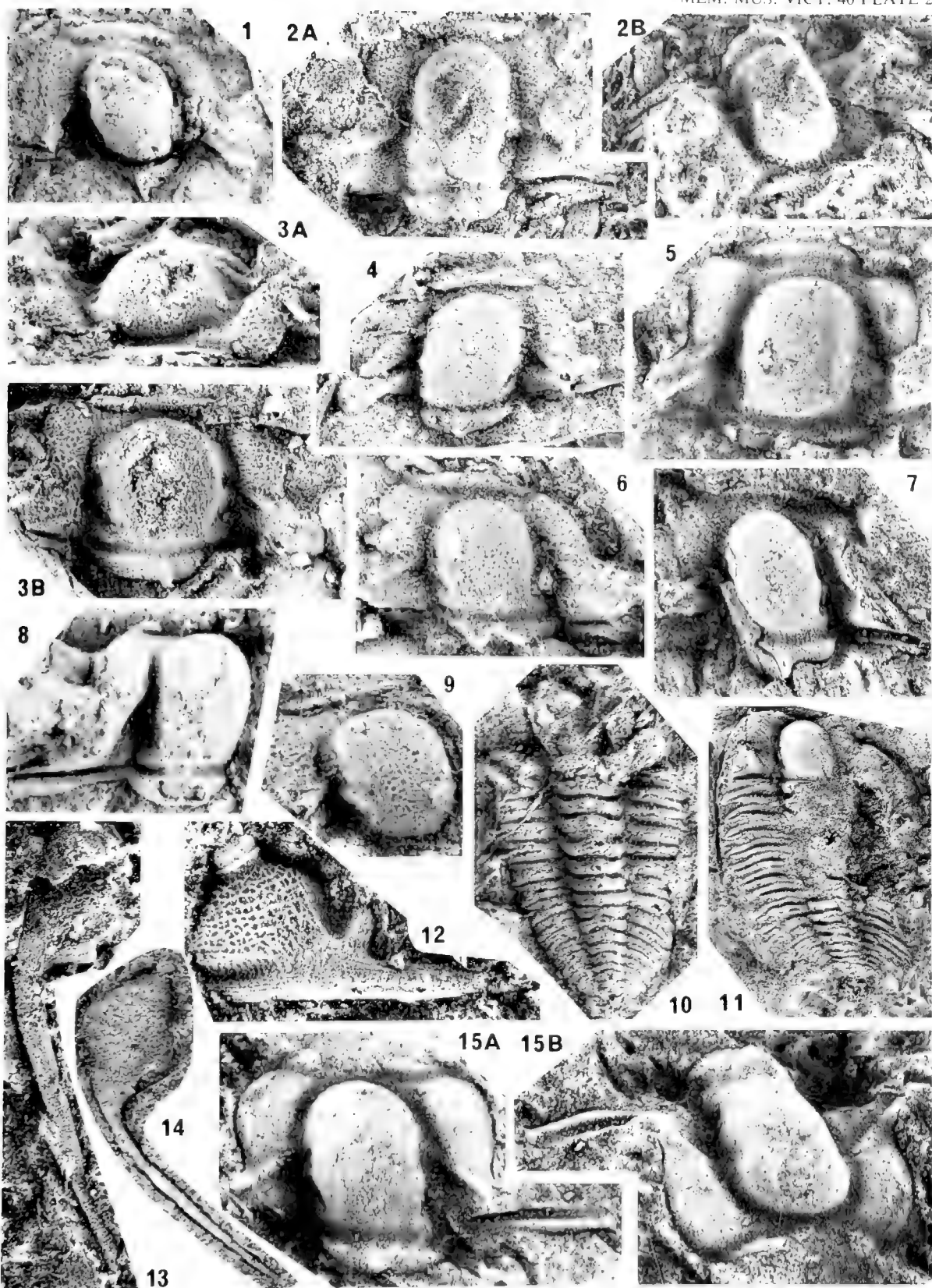
Figure 11. Unassigned hypostome No. 3. Mostly exfoliated internal mould of hypostome, NMVP71233, $\times 3$.

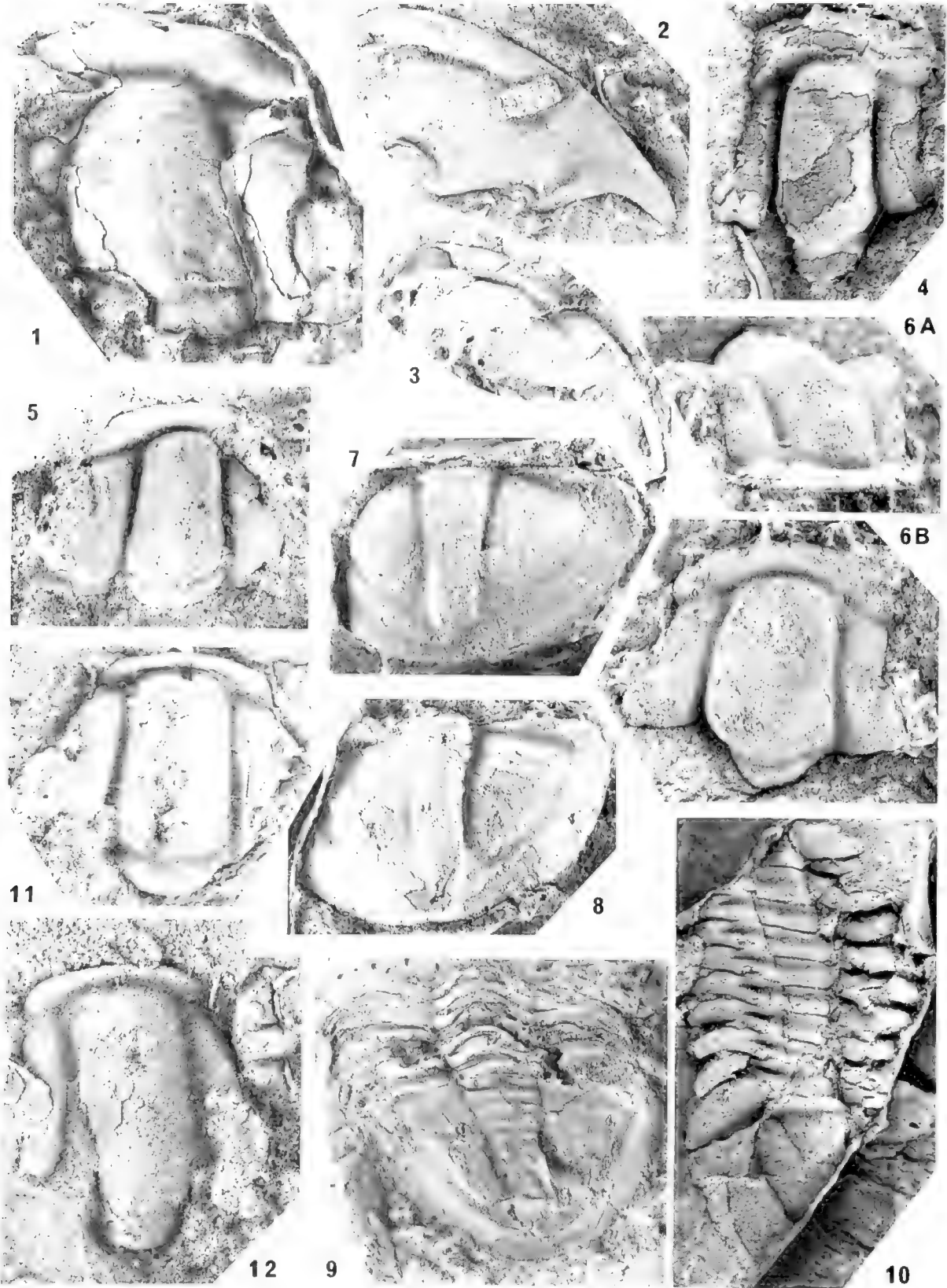
Figure 13. Unassigned hypostome No. 4. Latex cast from external mould of hypostome, NMVP71235, $\times 8$.

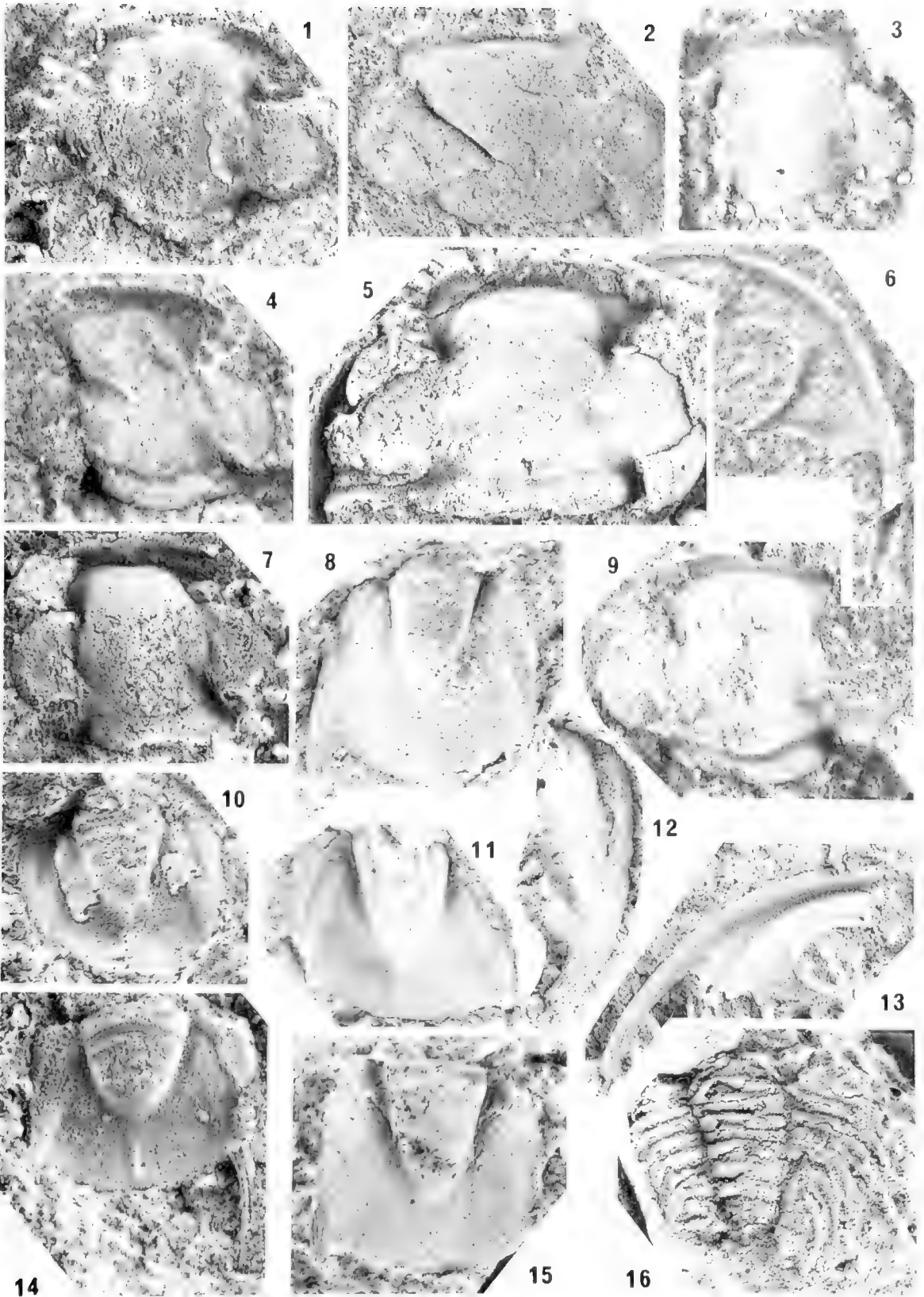
Figure 16. Unassigned hypostome No. 5. Internal mould of hypostome, NMVP71238, $\times 10$.

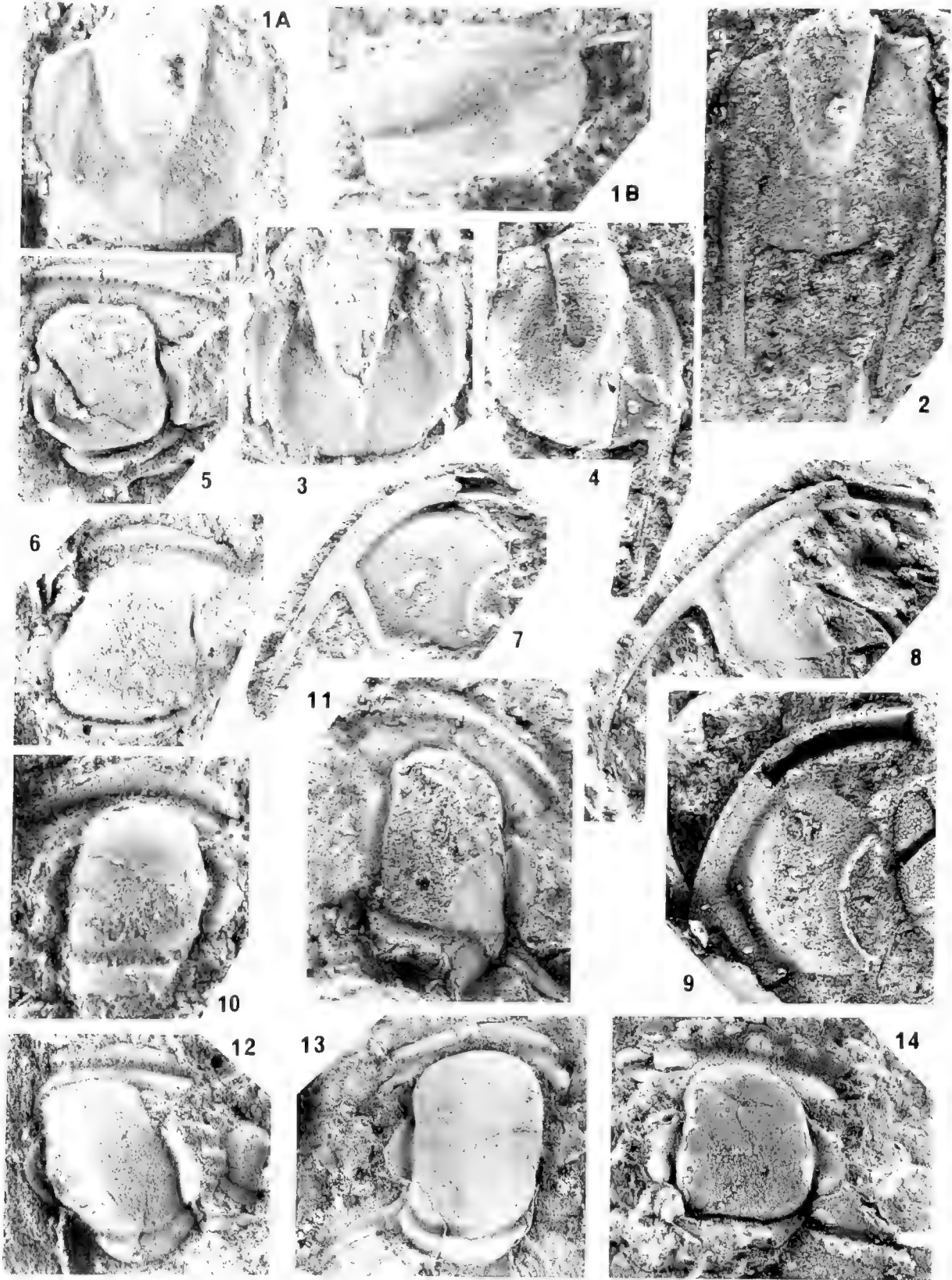


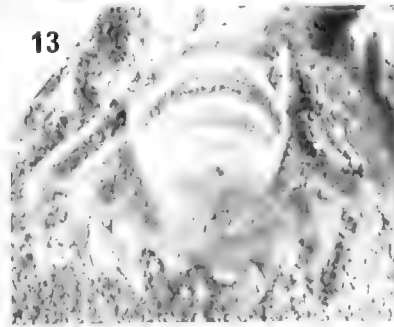
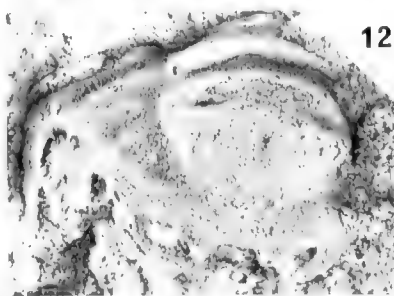
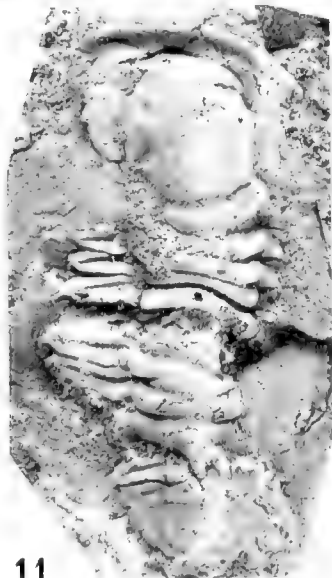
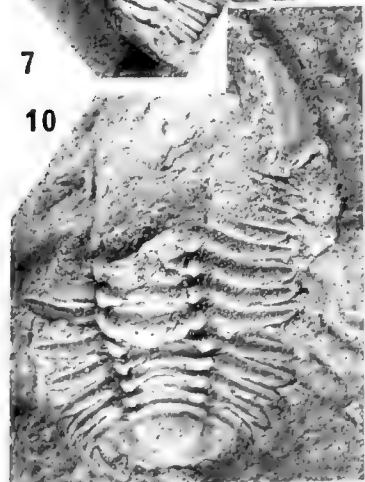
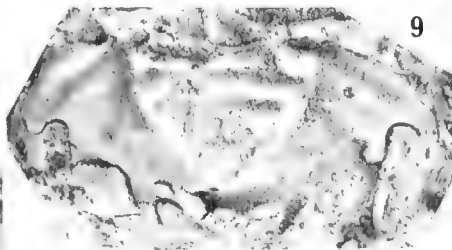
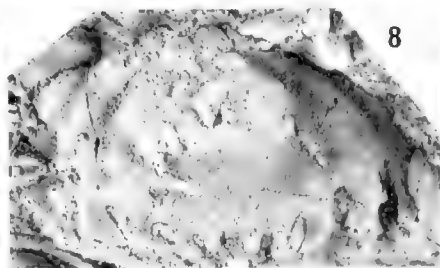
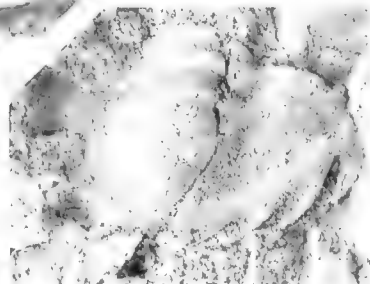
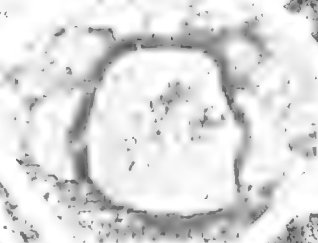
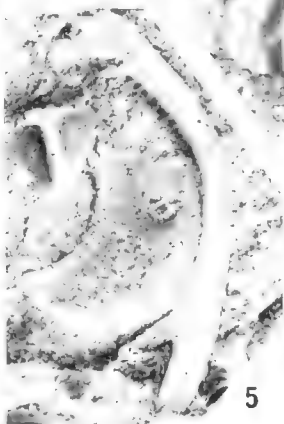
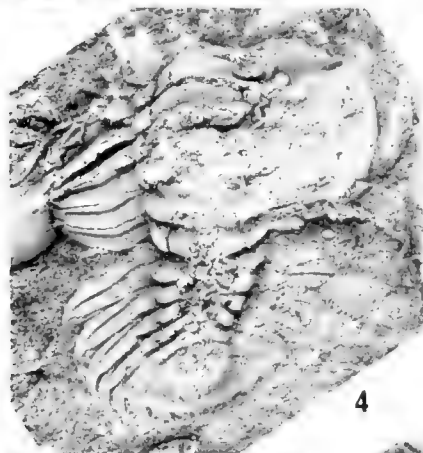
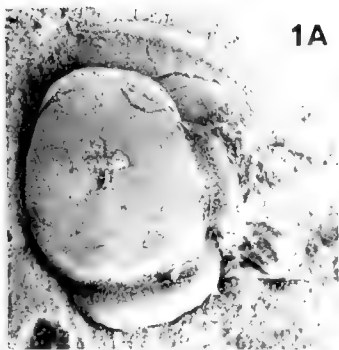


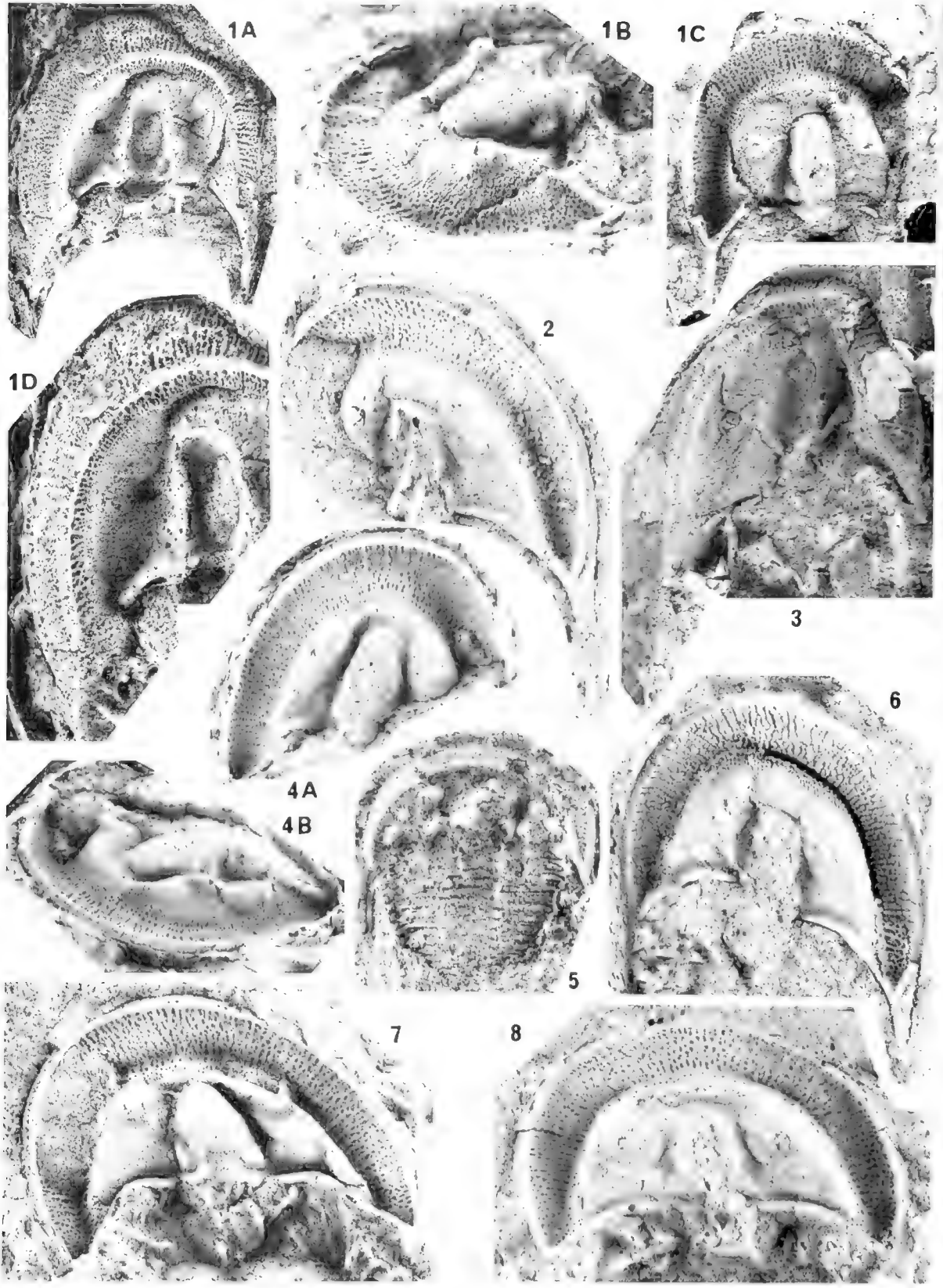


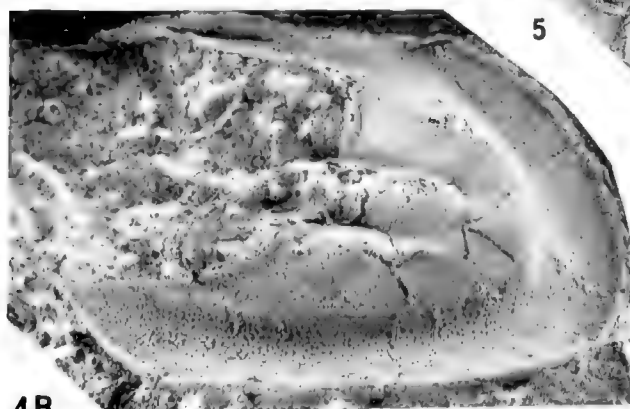
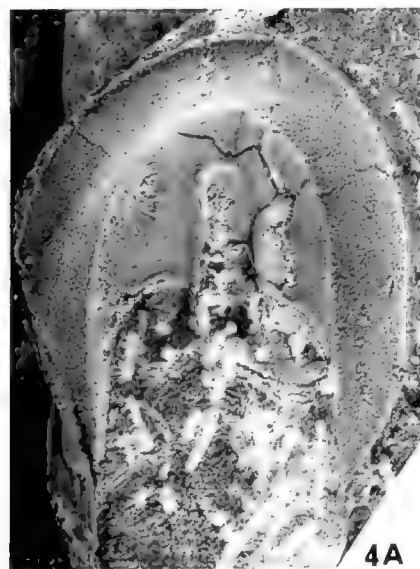
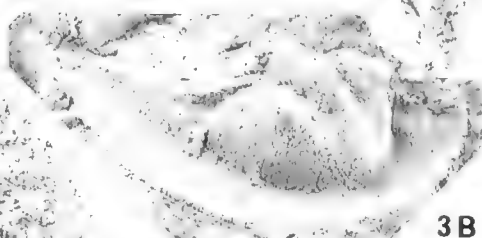
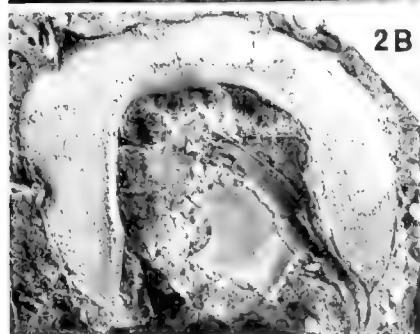
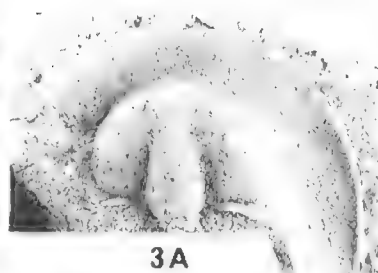
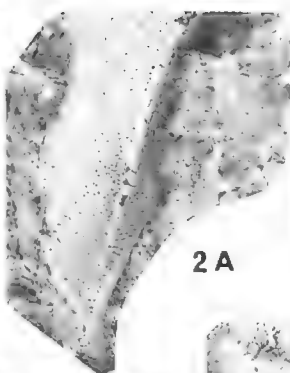
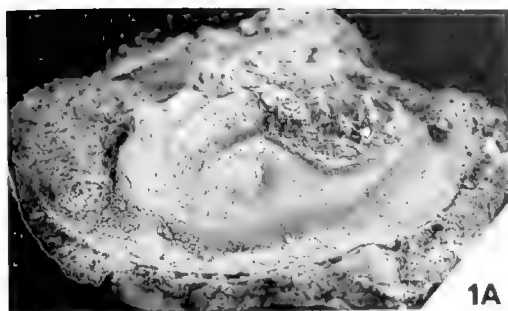


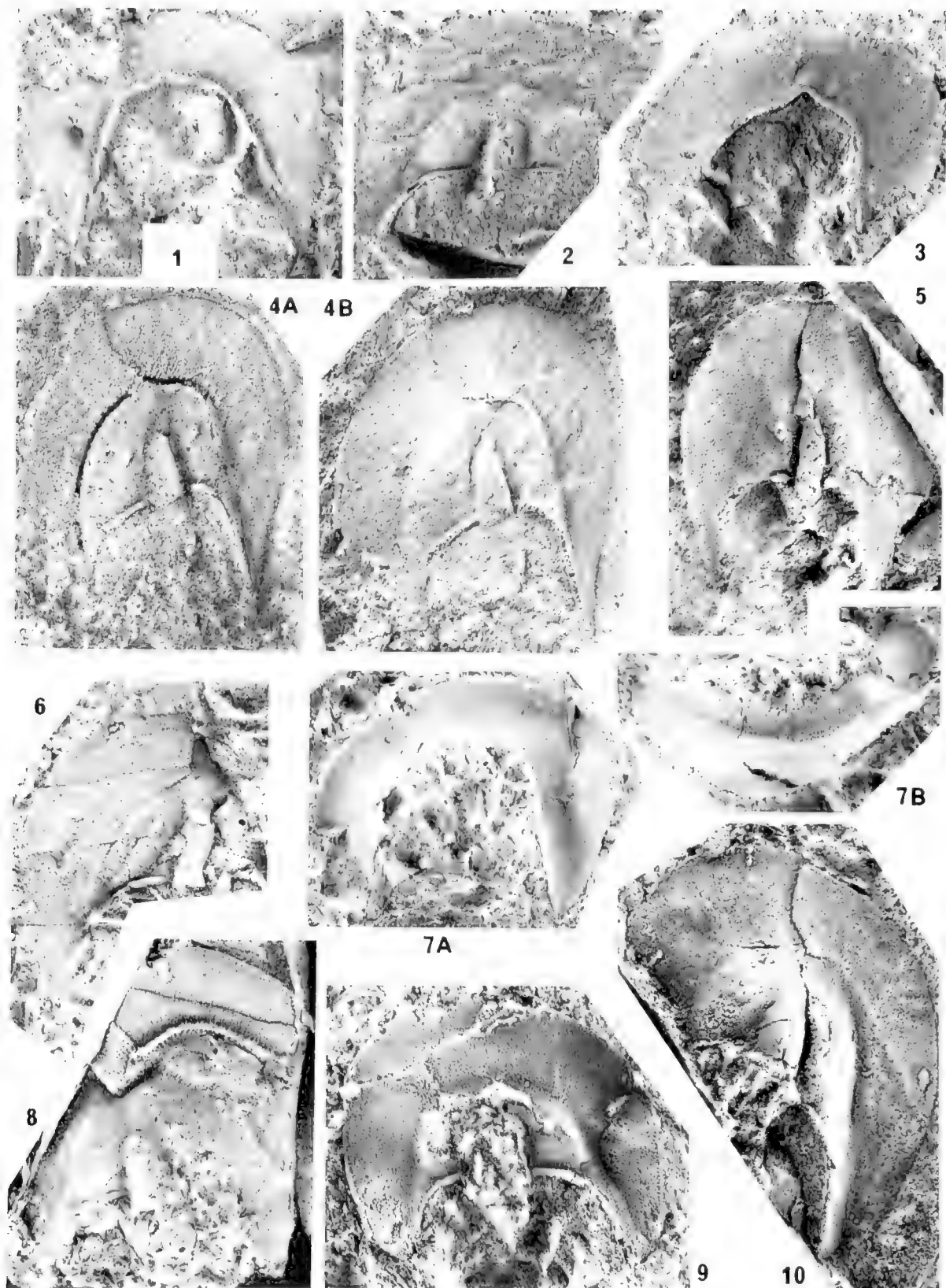


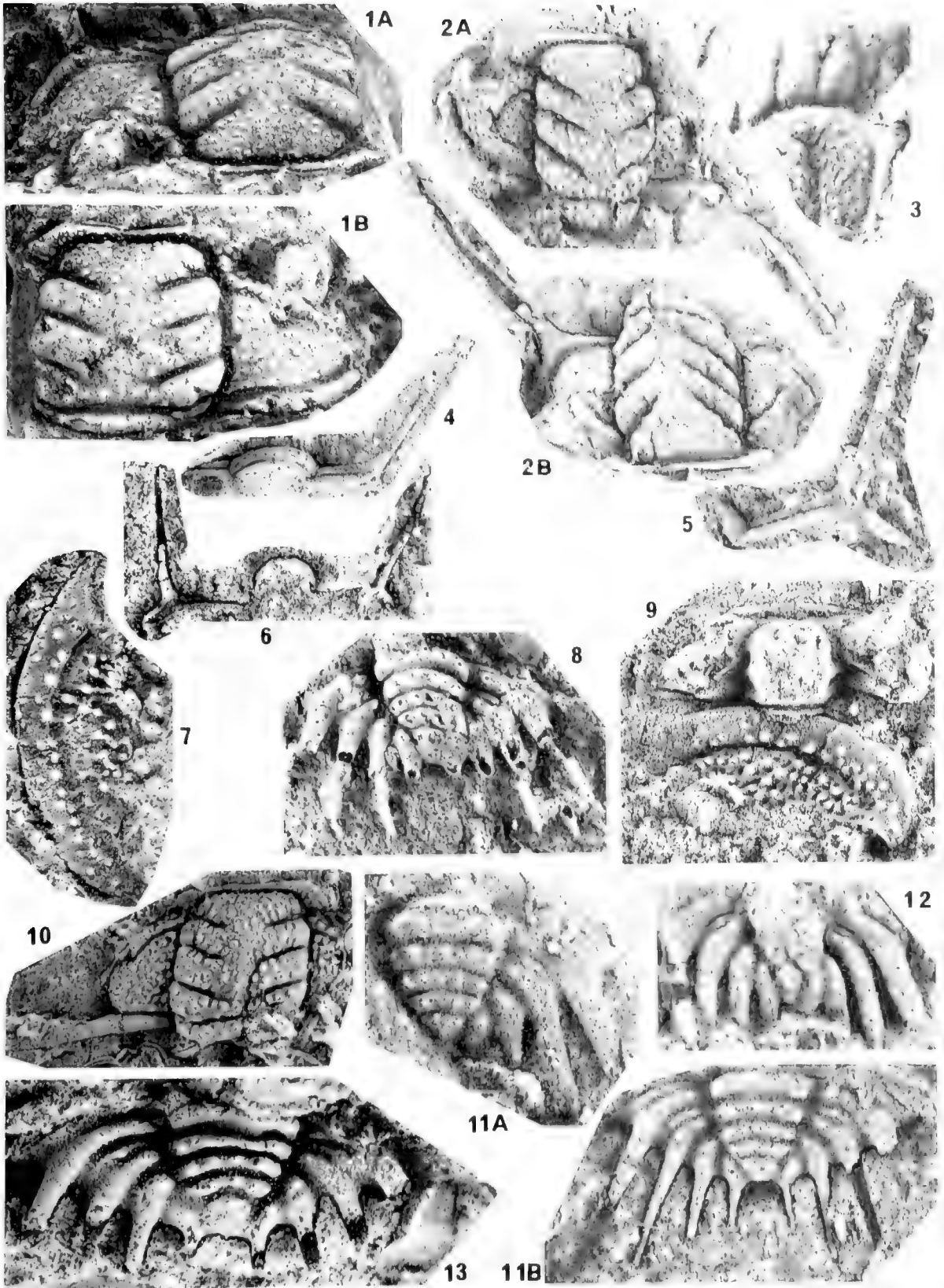


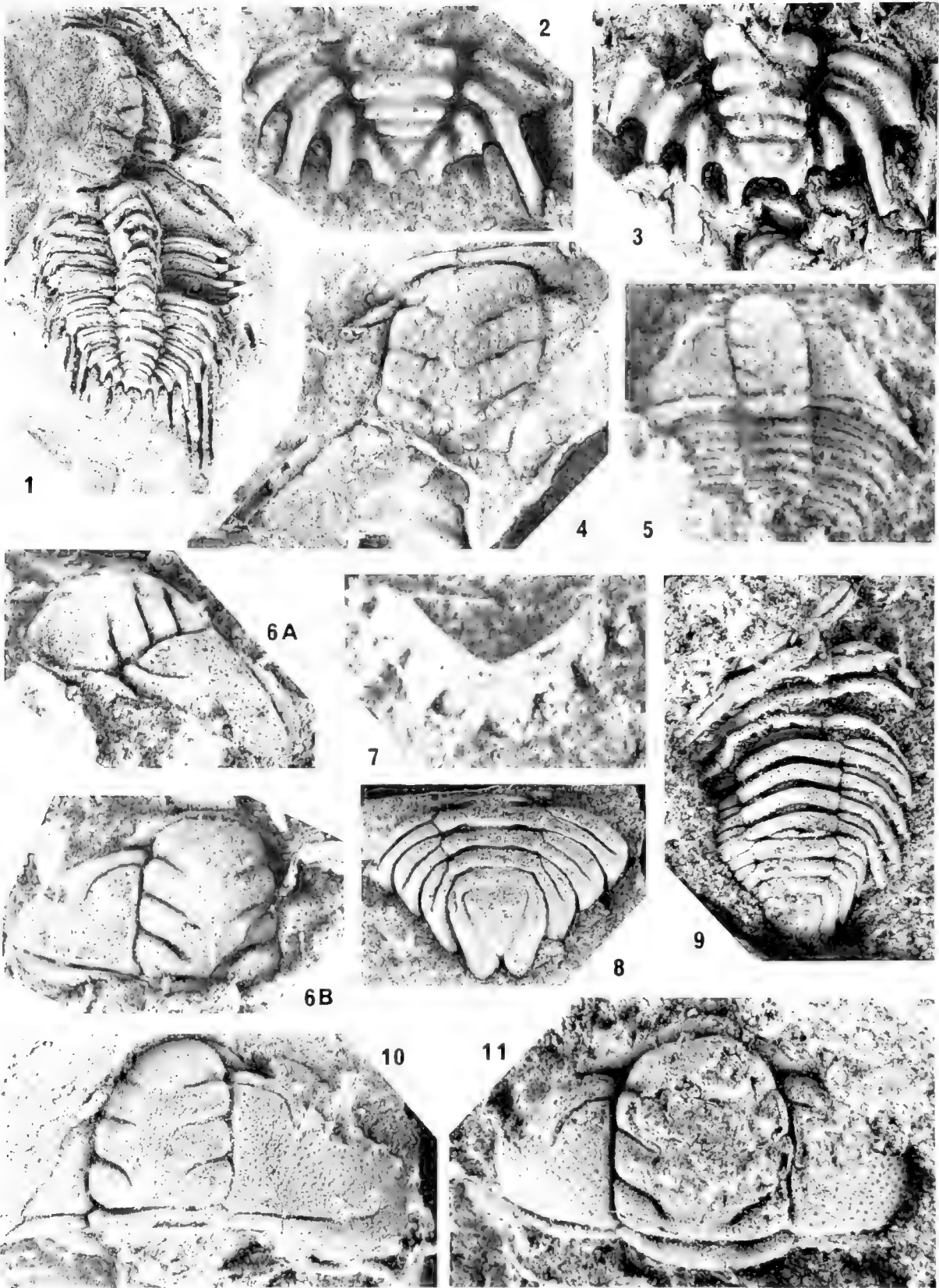


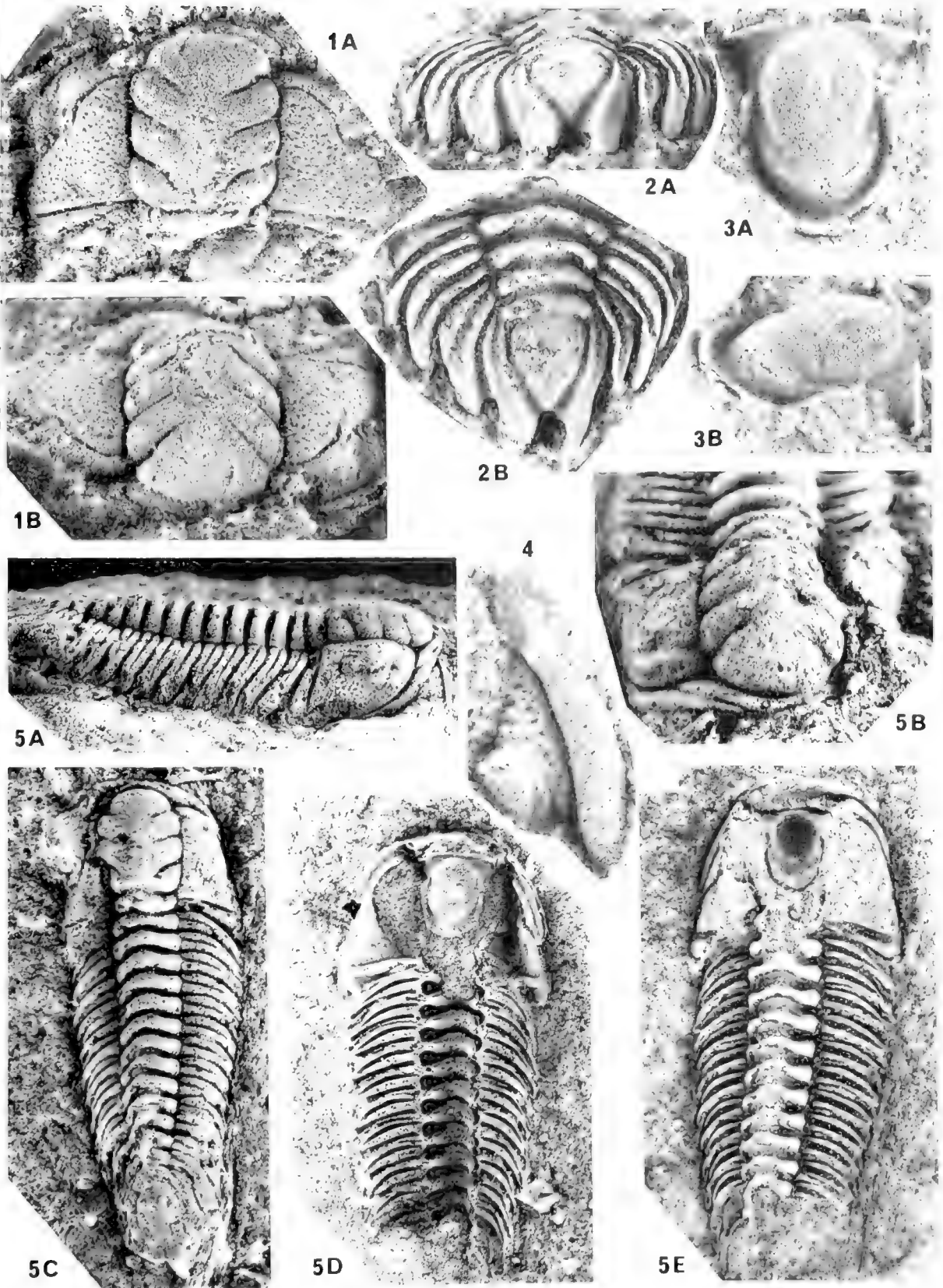






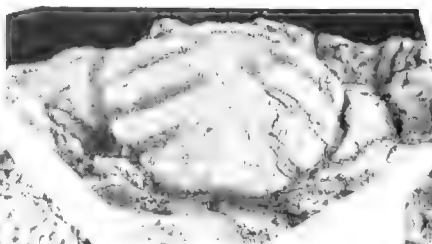








1



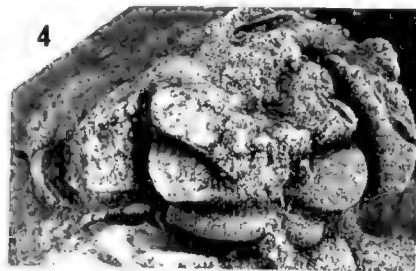
2A



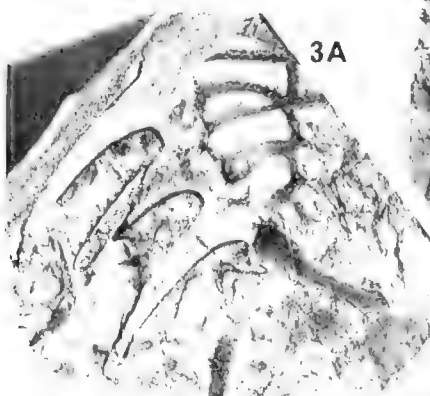
2B



3B



4



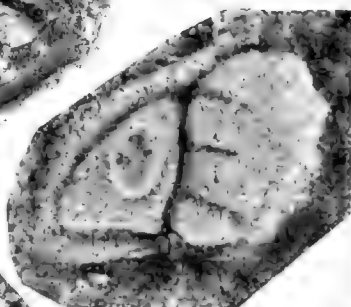
3A



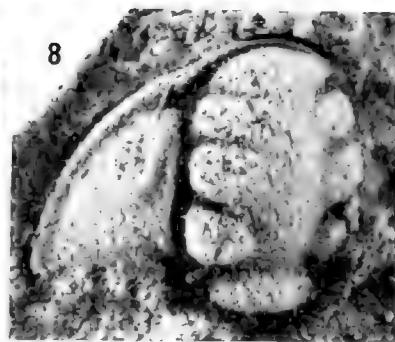
5



6



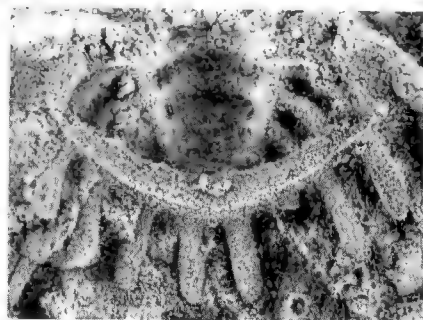
7



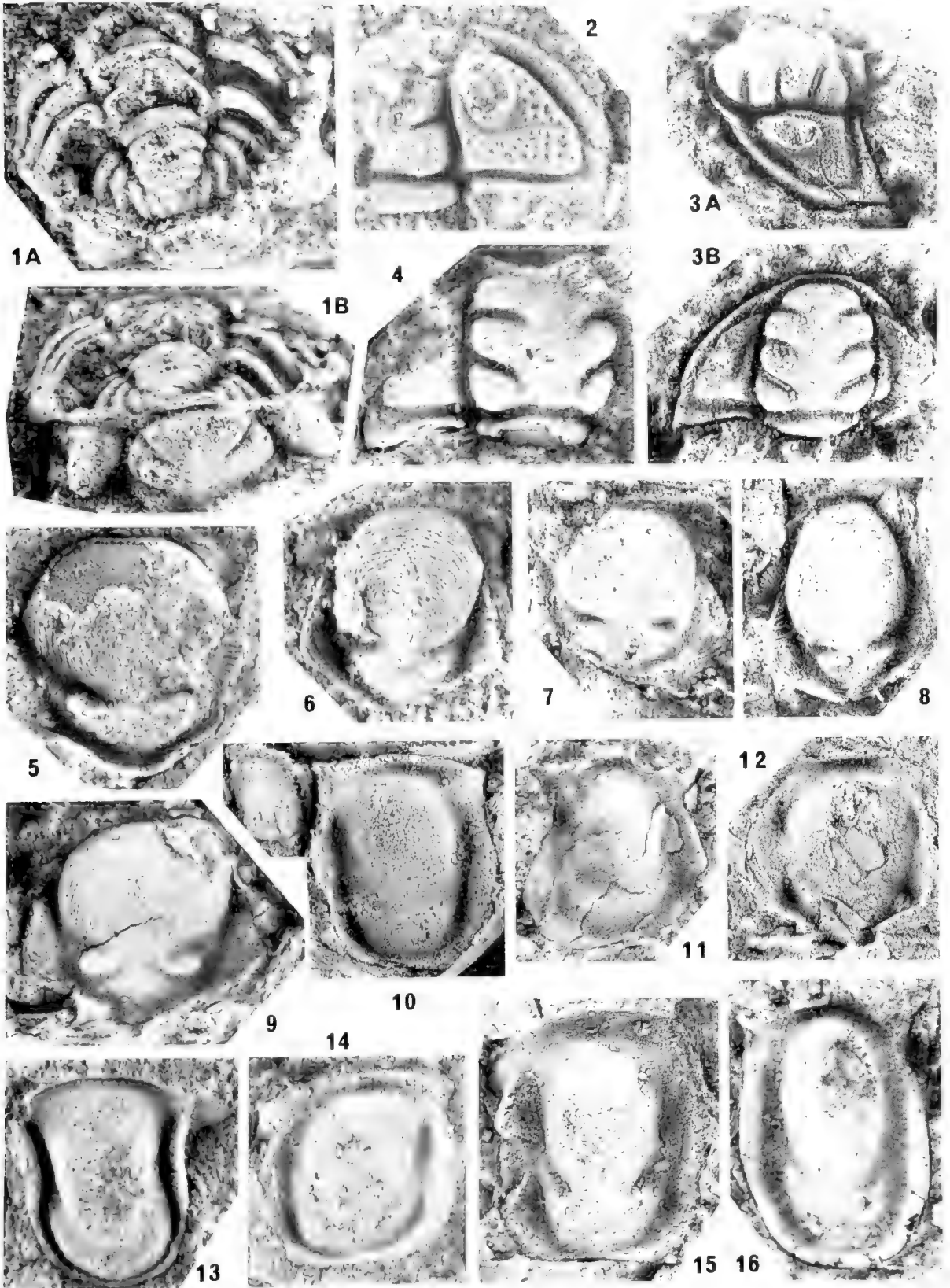
8



9



10



MEMOIRS
of the
MUSEUM OF VICTORIA
MELBOURNE AUSTRALIA

ISSN 0083-5986

Memoir 46
Number 2
January-June 1985

Director
Natural History

VACANT

Deputy Director
THOMAS A. DARRAGH

Editor
DOUGLAS M. STONE

PUBLISHED BY ORDER OF THE COUNCIL

© Museum of Victoria Council 1985

CONTENTS

NUMBER 2

4. New Species of *Cyathura* (Crustacea: Isopoda: Anthuridae) from estuaries of Eastern Australia.
By Gary C. B. Poore and Helen M. Lew Ton 89
5. *Apanthura*, *Apanthuretta* and *Apanthuropsis* gen. nov. (Crustacea: Isopoda: Anthuridae) from south-eastern Australia.
By Gary C. B. Poore and Helen M. Lew Ton 103
6. Australian Chaetiliids (Crustacea: Isopoda: Valvifera): A new genus, new species and remarks on the family. (Plate 34)
By Gary C. B. Poore 153

NEW SPECIES OF *CYATHURA* (CRUSTACEA: ISOPODA: ANTHURIDAE) FROM ESTUARIES OF EASTERN AUSTRALIA

BY GARY C. B. POORE AND HELEN M. LEWTON

Department of Crustacea, Museum of Victoria, Russell Street, Melbourne, Victoria 3000, Australia

Abstract

Cyathura aegiceras, *C. bruguiera* and *C. hakea* spp. nov., the only species of this genus so far known from Australia, are described. *Cyathura aegiceras* and *C. bruguiera* are found in estuaries of central-north Queensland and co-occur. *Cyathura hakea* is common in many estuaries and brackish coastal lakes of New South Wales, from the most eastern estuary and in a freshwater coastal lake in Victoria, and in an estuary draining to Moreton Bay, Queensland.

Introduction

The anthurid isopod genus *Cyathura* Norman & Stebbing is cosmopolitan, with at least 30 species known (Negoulescu and Wägele, 1984). Most are coastal species and many are estuarine. The eastern American species *C. polita* (Stimpson) and *C. carinata* (Krøyer) from Europe are the only two anthurideans whose biology has been studied (Amanieu, 1969; Burbanck, 1962; Burbanck and Burbanck, 1979).

Two new species are described from estuaries in central-north Queensland (18°S.) and a third from estuaries in southern Queensland, New South Wales and far eastern Victoria between 27°S. and 38°S. The third species is not known from well-sampled estuaries elsewhere in Victoria. Another anthuridean, *Cruranthura peroni* (Poore), also occurs in estuaries in southern Queensland, New South Wales and in Victoria ranges further west to the Gippsland Lakes (Poore, 1981).

Material for this study has come mostly from collections of the Queensland Museum, NSW State Fisheries (NSWSF), the Australian Museum Hawkesbury River Study, 1977-1978 (AMHRS), the Australian Museum Eurobodella Shire Estuary Survey, 1974 (AMESES) and the LaTrobe Valley Water and Sewerage Board, Traralgon (LVWSB). Specimens are lodged in the Australian Museum, Sydney (AM), the Queensland Museum, Brisbane (QM), and the Museum of Victoria, Melbourne (NMV). For an explanation of figure labelling see Poore (1984). Scales on figures are 1 mm.

Specific epithets are generic names of Australian flowering plants, following a pattern established for *Paranthura* by Poore (1984).

Anthuridae

Cyathura Norman & Stebbing, 1886

Diagnosis: Integument often pigmented, often with numerous fine hairs. Eyes usually present, sometimes absent. Antenna 1 flagellum of at most 4 articles, with 3 terminal aesthetascs. Antenna 2 flagellum short, of very few short articles. Mandibles symmetrical, not sexually dimorphic; incisor, lamina dentata and blunt molar present; palp 3-articled, article 3 as long as 2, with a longitudinal row of setae. Maxilliped of 4 articles, endite absent or reduced; article 4 terminal (suture oblique), about one-half length of article 3, with 4-5 mesial setae.

Pereopod 1 subchelate, article 6 swollen, with a tooth on the palm. Pereopods 2 and 3 with articles 6 only very slightly more swollen than posterior pereopods. Pereopods 4-7 with article 5 triangular, its anterior margin free.

Pleon short (about as long as pereonite 7), pleonites 1-5 fused, pleonite 6 free or fused to telson. Pleopod 1 exopod operculiform, endopod without marginal setae. Pleopods 2-5 with endopods each bearing 1 seta. Uropodal endopod short, more or less square or triangular. Telson with 2 basal statocysts, apex with long setae, no long dorsal setae.

Male antenna 1 with short flagellum of 4-5 very short articles, each bearing numerous aesthetascs.

Types-species: *Anthura carinata* Krøyer, 1848.

Remarks: The genus *Cyathura* has been defined clearly by Barnard (1925) and more recently by Wägele (1981). *Cyathura* shares with *Apanthura* and related genera antenna 1 with three aesthetascs, triangular-trapeziform article 5 on pereopods 4-7 and telson with several apical long setae. Its closest relative is *Mesanthura* with which it shares a broad terminal maxillipedal article, short male antenna 1 flagellum, and no maxillipedal endite.

Wägele (1979) described in detail the homology of the mouthparts of *Cyathura carinata*, the only anthuridean studied in this way.

The male of species of *Cyathura* possesses a retractile flagellum on antenna 1. The flagellum is very short and capable of being telescoped into the terminal article of the peduncle. This phenomenon was discussed in detail by Wägele (1982).

The phylogenetic interrelationships of the species of *Cyathura* have been explored in two recent contributions. Wägele (1982) examined the morphology of the apex of the male appendix masculina but reached few conclusions. Botosaneanu and Stock (1982) divided the genus into two subgenera, *Cyathura* s.s. and *Stygocyathura*, on the basis of several characters, the most significant being the method of articulation of the uropodal exopod. In *Cyathura*, which contains mainly marine species, the exopod is shaped like an "elephant's ear" and its articulation is long. In contrast, in *Stygocyathura*, which contains only stygobiontic Caribbean species, the exopod is linear and its articulation short and transverse. Division of the subgenera is also supported, more or less, by differences in fusion of the telson, palm of pereopod 1, proportions of pereopodal articles, setation and first pleopods. We support this division of the genus and believe that *Stygocyathura* is a monophyletic group which has invaded stygobiontic environments in the Caribbean and Central America. Botosaneanu and Stock (1982) suggested that the New Caledonian species, *Cyathura numeae* Wägele, which lives in a hypogean interstitial environment represents an intermediate form. It is our belief that this species is a true member of the subgenus *Cyathura* and its similarity to the

stygobiontic species is a convergence resulting from adaptation to its peculiar environment. Similar adaptations are shown by the unrelated paranthurid *Cruregens fontanus* Chilton. *Cyathura numeae* is most closely related to two species geographically quite separate, *C. cubana* Negoulescu and *C. aegiceras* sp. nov. This lends support to the idea that *Cyathura* s.s. is a world-wide grouping and *Stygocyathura* is a local monophyletic offshoot.

One of the characters used to differentiate the two new subgenera was the degree of fusion of the telson to pleonite 6. Botosaneanu and Stock (1982) believed that in all species of *Cyathura* s.s. the telson was free; this is not the case in *C. aegiceras* but telson fusion is a widespread phenomenon in the family and probably of little phylogenetic significance.

All Australian species fall within the subgenus *Cyathura* as predicted by Botosaneanu and Stock (1982).

Key to eastern Australian species of *Cyathura*

1. Telson tapering; pereopod 2 with article 6 rectangular and straight *C. aegiceras*
- Telson with convex lateral margins, widest at midpoint; pereopod 2 with article 6 linear and curved 2
2. Uropodal endopod about as long as wide; exopod widest at midpoint; body about 10 × as long as wide *C. hakea*
- Uropodal endopod almost twice as long as wide; exopod widest distally; body about 15 × as long as wide *C. bruguiera*

Cyathura aegiceras sp. nov.

Figures 1-3

Material examined: 3 females, 3.4-4.4 mm; 4 juveniles, 2.7-5.0 mm:

Holotype: female, 4.4 mm, QMW10033 (with one slide). Qld, Murray River, north of Cardwell (18°16'S., 146°01'E.), P. Davie, May 1978.

Paratypes: Qld, type locality, QMW10039 (1), QMW10600(1), QMW10603(2), NMVJ 4168(1).

Other material: Qld, Daintree River, D. Hammond, Jun 1981, QMW10029(1).

Description: *Female.* About 7 × as wide. Integument smooth, with few scattered fine setae;

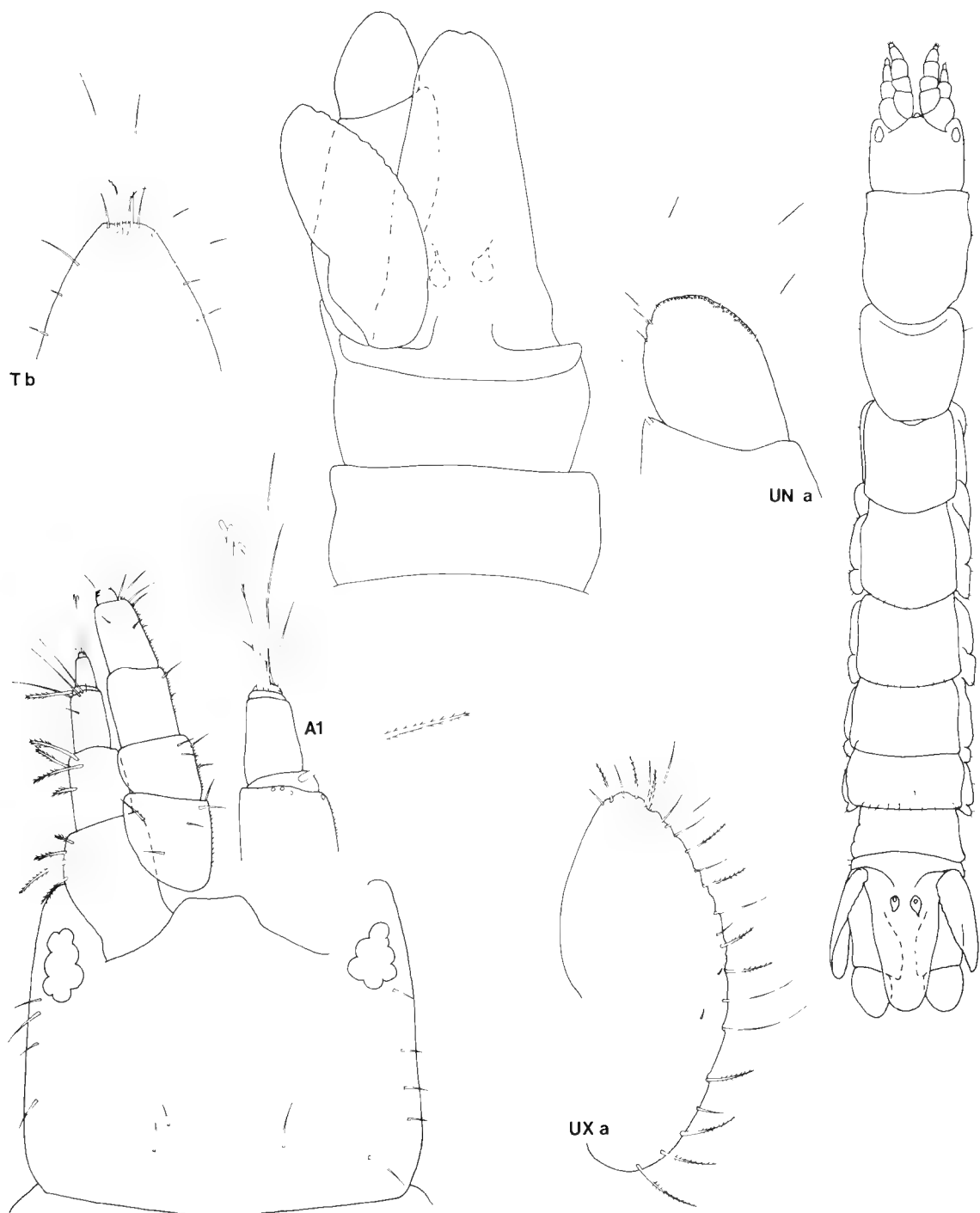


Figure 1. *Cyathura aegiceras*. Female, 4.4 mm, QMW10033; a, female, 3.4 mm, QMW10600; b, juvenile, 3.7 mm, QMW10600.

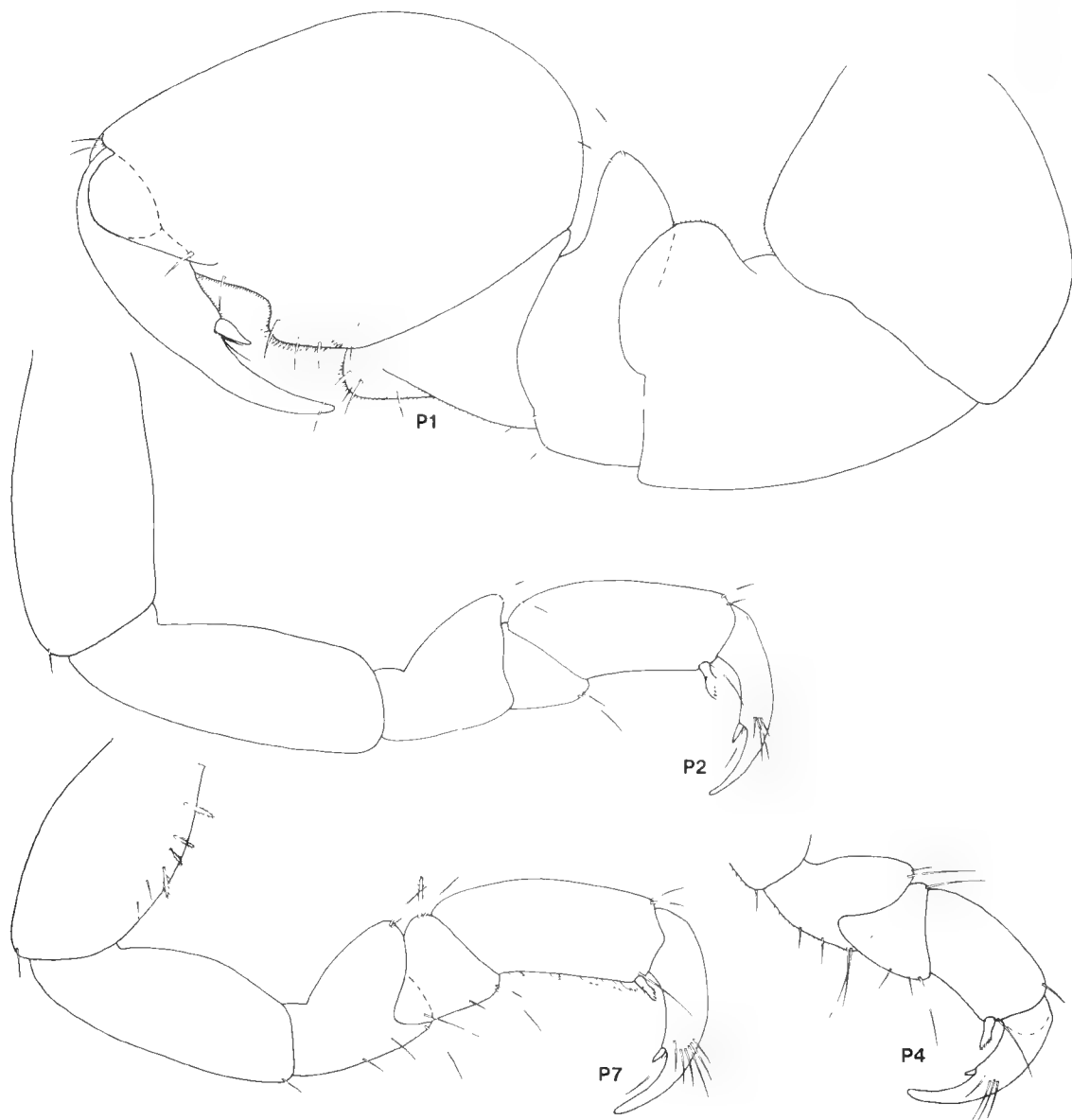


Figure 2. *Cyathura aegiceras*. Female, 4.4 mm, QMW10033.

shallow dorsal pits on pereonites 4-6. Dorsolateral margins of pereonites 4-7 produced as small lobes posterior to base of legs. Head $0.8\times$ as long as wide; rostrum shorter than lateral lobes, truncate. Antenna 1 reaching midway along article 5 of antenna 2; flagellum of 4 articles of which the second is the longest; with 3 terminal aesthetascs. Antenna 2 flagellum of

very compressed articles, one-sixth length of last article of peduncle.

Mandibular molar narrow, truncate; lamina dentata with 12 saw-teeth; incisor blunt. Palp article 2 twice as long as article 1; article 3 is $1.5\times$ as long as article 1; first and second articles each with 1 seta, third with 5 terminal pectinate setae. Maxilliped covered with few fine

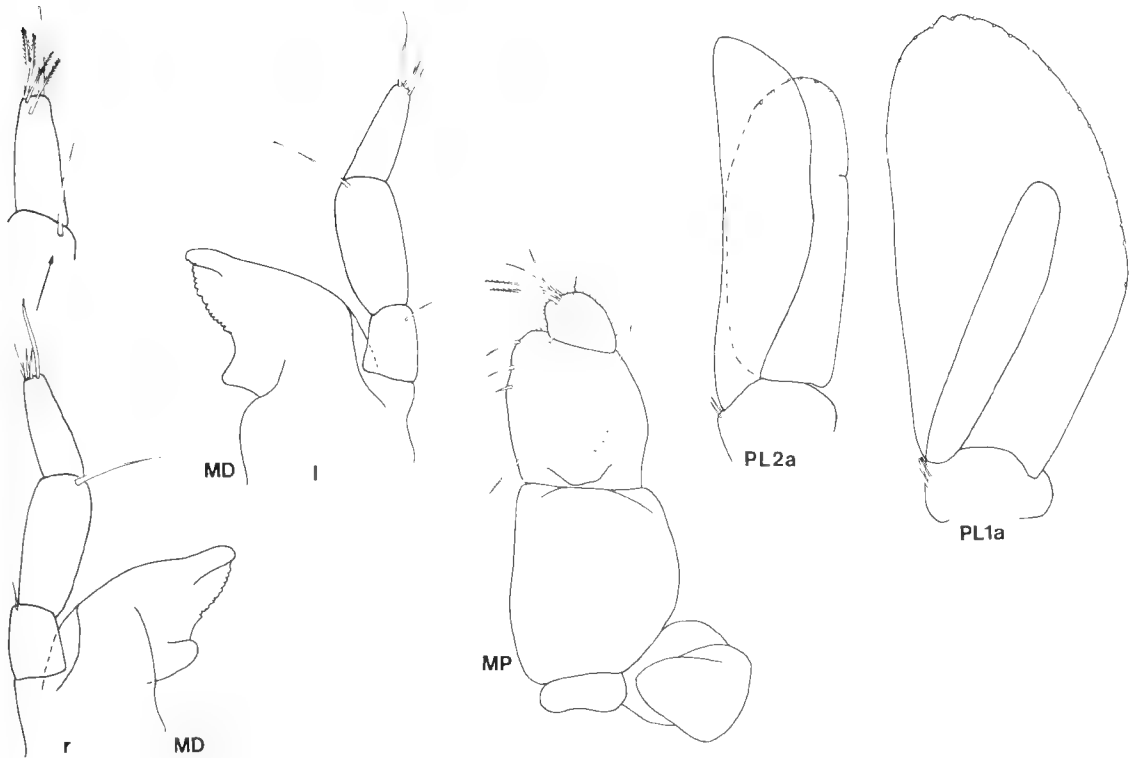


Figure 3. *Cyathura aegiceras*. Female, 4.4 mm, QMW10033; a, female, 3.4 mm, QMW10603.

hairs, with a short endite; article 1 vaguely discernible; article 3 with 4 mesial setae, 1 mesio-facial and 1 latero-facial; article 4 about one-quarter as long as 3, with 4 disto-mesial setae.

Pereopod 1 with a swollen article 6; article 5 with an obtuse posterodistal tooth; palm of article 6 axial, stepped midway along and bearing numerous short spines. Pereopods 2 and 3 with few posterior setae; article 5 not posteriorly lobed; article 6 not curved, not more swollen than in posterior pereopods; article 7 with a secondary claw one-third as long as unguis.

Pereopods 4-6 of similar size, setose along posterior margin and with a secondary claw on dactyl. Pereopod 7 with a longer article 6 than more anterior limbs, without a secondary claw. Pleopod 1 exopod operculiform, with about 25 marginal setae; endopod two-thirds length of exopod, without setae. Pleopod 2 endopod longer than exopod; exopod with a partial suture, with 7-10 setae; endopod without setae.

Pleon about $1.5\times$ as long as wide, as long as pereonite 7; pleonites 1-5 fused, pleonite 6 fused to telson. Uropodal endopod reaching beyond end of telson, $1.5\times$ as long as wide, widest proximally; exopod $2.2\times$ as long as wide, dorsal margin gently convex, distal apex acute-rounded. Telson $1.8\times$ as long as wide, widest proximally and tapering evenly, 3 pairs of dorsal-lateral setae distally, 3 pairs in an apical concavity.

Male: Unknown.

Colour: Pale yellow.

Distribution: Central-north Queensland, estuaries.

Etymology: *Aegiceras* is a genus of mangrove.

Remarks: All species of the subgenus *Cyathura* are morphologically quite similar but *C. aegiceras* exhibits two unique features. Pleonite 6 is fused to the telson and pereopod 2 has a relatively short article 7 (it is usually longer and curved). Its tapering telson is similar to that of

C. numeae Wägele, but this smaller species is blind and found in an hypogean interstitial habitat. A similar species from an estuarine mangrove habitat is *C. cubana* Negouescu. Like *Cyathura aegiceras*, *C. cubana* is a broad species with compact pereopod 2 but the telson of this species is parallel-sided rather than tapered.

***Cyathura bruguiera* sp. nov.**

Figures 4, 5

Material examined: 5 males, 1 female, 14 juveniles; 3.1-8.5 mm:

Holotype: juvenile, 8.5 mm, QMW10040 (with one slide). Qld, Murray River, north of Cardwell (18°16'S., 146°01'E.), P. Davie, May 1978.

Paratypes: Qld, type locality, QMW10605 (1 male, 8 juveniles), QMW10034(2), QMW10035(2), QMW10036(1), QMW10037(2), QMW10038(1), NMVJ4170(2).

Description: *Juvenile.* About 15× as long as wide. Integument smooth; shallow dorsal pits on pereonites 4-6. Head about as long as wide; rostrum shorter than lateral lobes, truncate. Antenna 1 reaching midway along article 4 of antenna 2; flagellum of 4 articles, with 3 terminal aesthetascs. Antenna 2 flagellum of several very short articles, one-third length of last article of peduncle.

Mandibular molar narrow, truncate; lamina dentata with 16 saw-teeth; incisor blunt. Palp article 2 twice as long as article 1; article 3 1.5× as long as article 1; all articles with fine hairs, second with 3 setae, third with a terminal comb of 7 spaced pectinate setae. Maxilliped covered with fine hairs, with a broad short endite; article 3 with 5 mesial setae, 1 mesio-facial and 1 antero-facial; article 4 about half as long as 3, with 4 mesial setae.

Pereopod 1 with a swollen but strongly tapering article 6; article 5 with an acute but not prominent posterodistal tooth; palm of article 6 axial, a tooth midway along and a marginal row of about 10 setae. Pereopods 2 and 3 posteriorly setose and bearing fine hairs; article 5 moderately posteriorly lobed; articles 6 curved, only slightly more swollen than in posterior pereopods; article 7 with a secondary claw almost half as long as unguis.

Pereopods 4-6 of similar size, setose along posterior margins; lacking a secondary claw on dactyl. Pereopod 7 with longer article 6 than more anterior limbs. Pleopod 1 exopod operculiform, with about 40 marginal setae; endopod two-thirds length of exopod, without setae. Pleopod 2 rami equal in length; exopod with a partial suture, about 15 setae; endopod without setae.

Pleon about as long as wide, as long as pereonite 7; pleonites 1-5 fused. Uropodal endopod reaching beyond end of telson, about 1.8× as long as wide, widest proximally; exopod 1.9× as long as wide; dorsal margin widest distally, ventral apex obtusely rounded. Telson 2.4× as long as wide, widest at about midpoint, few short marginal and submarginal setae distally, 3 pairs in an apical concavity.

Male: Differing from juveniles and female in antenna 1; flagellum of 5 articles, telescoping into terminal article of peduncle, and bearing numerous aesthetascs ventrally and distally. Pereopods all more elongate, pereopod 1 with mesial row of short setae. Pleopod 2 with appendix masculina reaching little beyond endopod.

Colour: Variable but colour on pleon, head and antennae are most persistent elements.

Distribution: Central-north Queensland, estuaries.

Etymology: *Bruguiera* is a genus of mangrove.

Remarks: *Cyathura bruguiera* is an elongate species separated from *C. aegiceras* with which it co-occurs by the convex lateral margins of the telson and more elongate article 6 of pereopod 2, typical of most of its cogenors.

***Cyathura hakea* sp. nov.**

Figures 6-8

anthurid.—Timms, 1973: 10ff.—Williams, 1980: 155, fig. 62.1.

Material examined: 62 males, 180 females, 203 juveniles; 4.1-18.1 mm:

Holotype: juvenile, 10.7 mm, AMP33592 (with one slide). NSW, Georges River, Milperra (33°56'S., 150°58'E.), NSWSF stn 28, 29 Nov 1972.

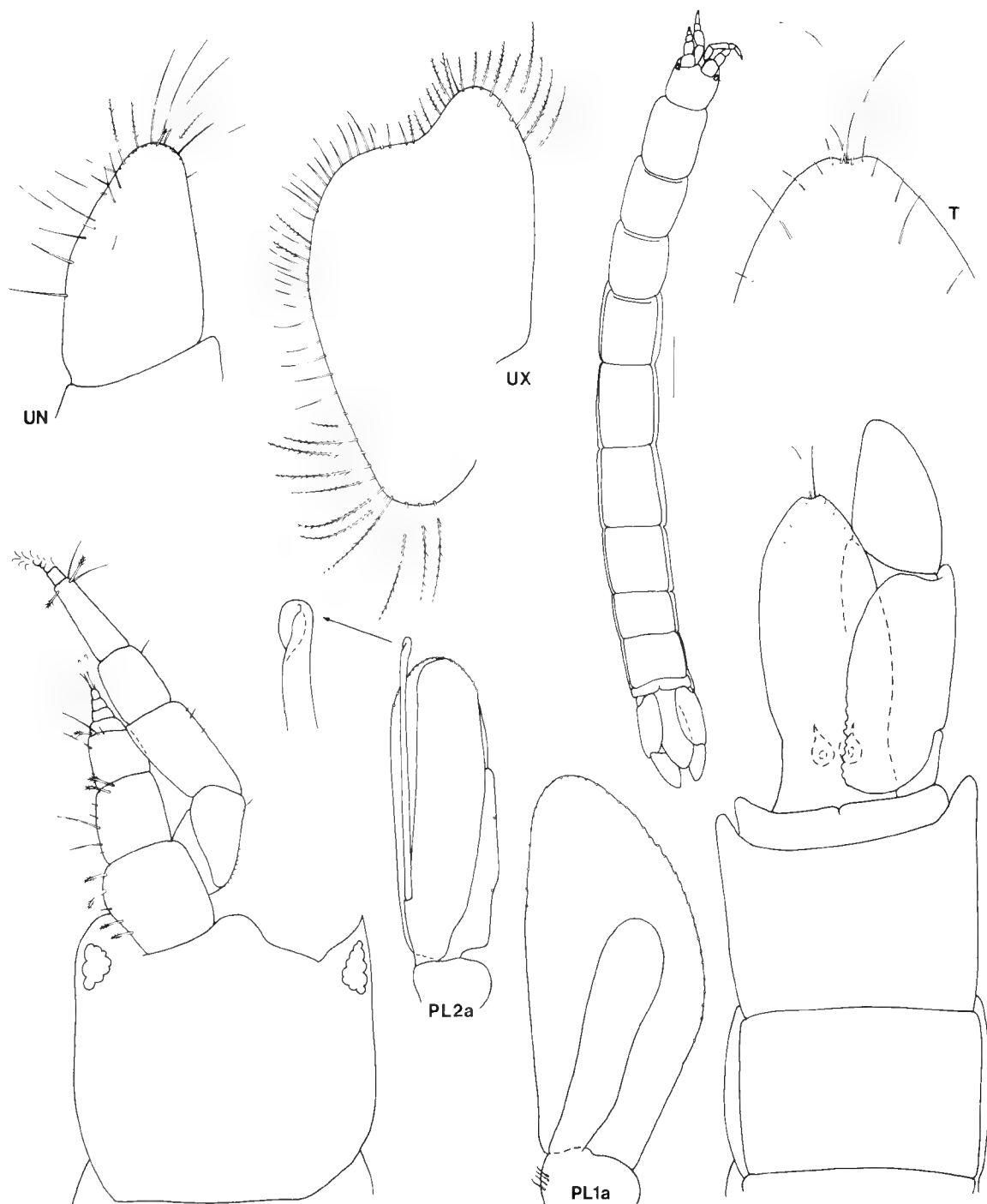


Figure 4. *Cyathura bruguiera*. Juvenile, 8.5 mm, QMW10040; a, male, QMW10605.

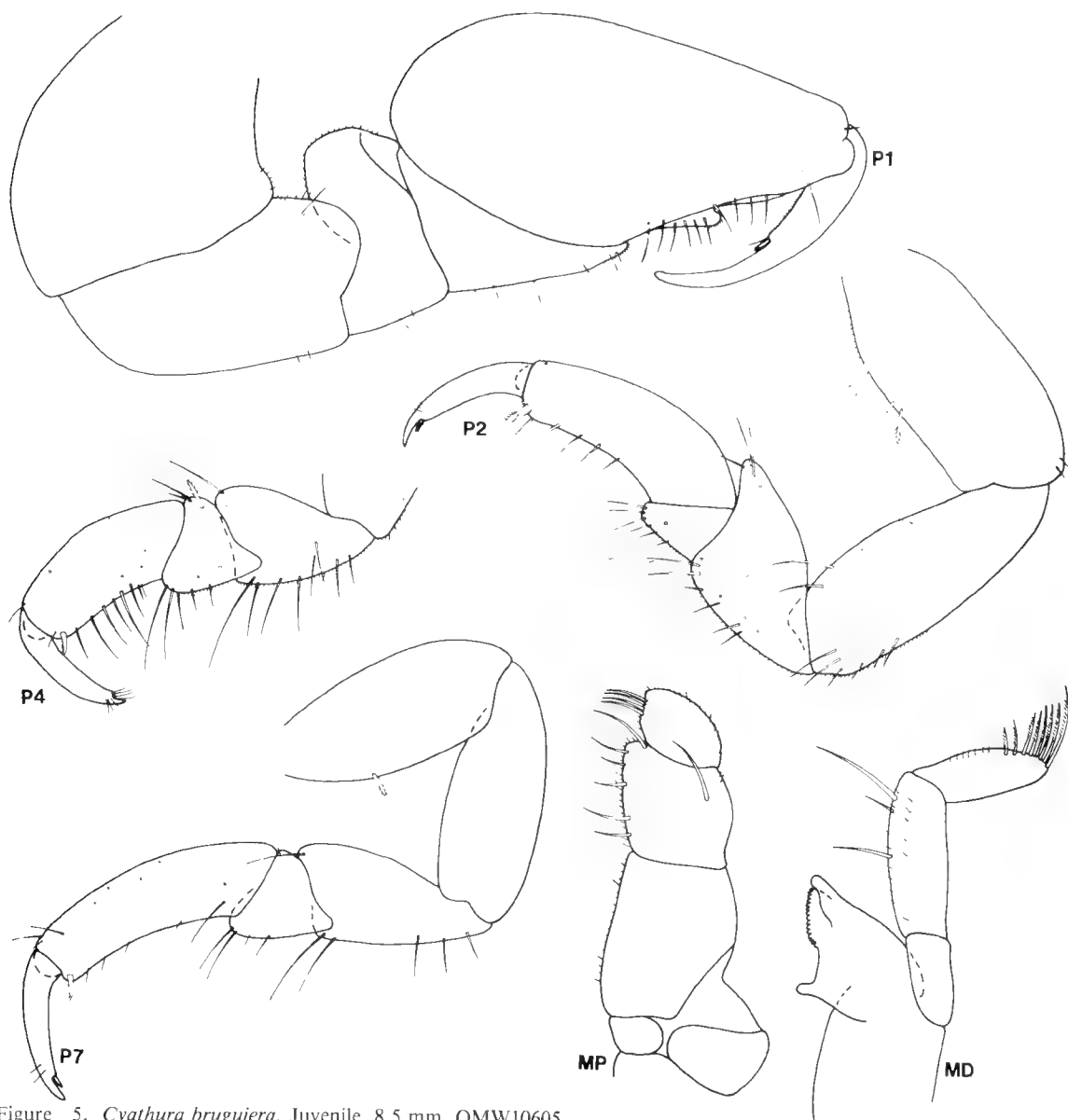


Figure 5. *Cyathura bruguiera*. Juvenile, 8.5 mm, QMW10605.

Paratypes: NSW, type locality, AMP33593 (1 male), AMP33594 (1 female), AMP24976(37), NMVJ2889(5).

Other material. Qld. Serpentine Creek, left branch, 0.5 km from mouth, B. Campbell, 1 Aug 1972, QMW4230(2).

NSW. Georges River Estuary, 21 NSWFS stations, Oct-Nov 1972: AMP24724-8 (37 specimens); AMP24958-60, P24962-74(243).

Georges River, D. Dexter, AMP31042(1). Queens Lake, NSWFS stations: NMVJ2885(3), NMVJ2886(3). Myall Lake, P. Hutchings, Sep 1975: AMP25194-8(14), AMP33597-601(5). Smiths Lake: University of NSW, 11 Mar 1980, NMVJ2876(1); NSWFS station, 17 Dec 1979, NMVJ2887(1). Lake Macquarie: NSWFS station, NMVJ2879-84(36); K. Robinson, 17 Jul 1979, NMVJ2875(3). Tuggerah Lake, B. J.

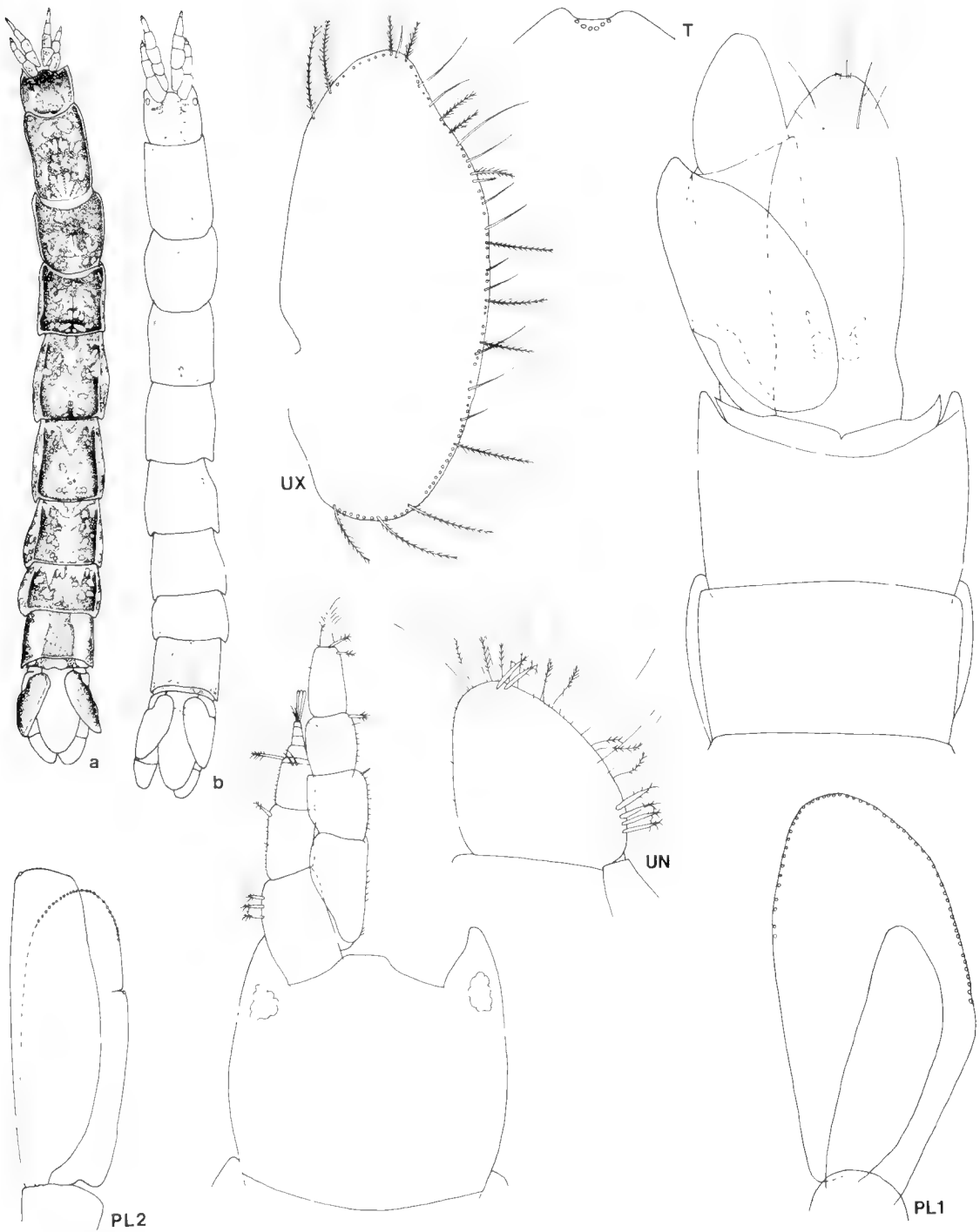


Figure 6. *Cyathura hakea*. Juvenile, 10.7 mm, AMP33592; a, male, 10.4 mm, AMP33593; b, juvenile, 10.3 mm, AMP24974.

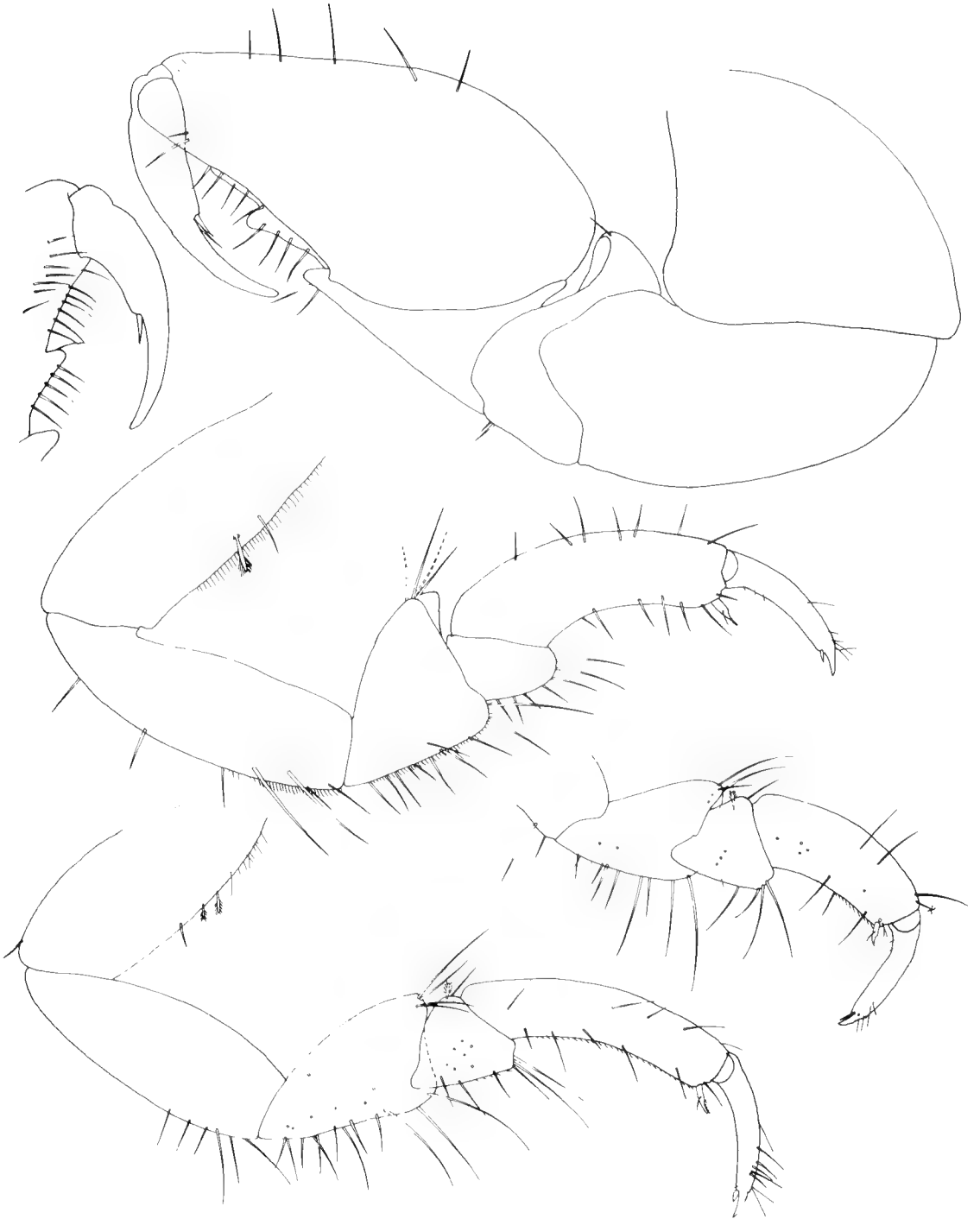


Figure 7. *Cyathura hakea*. Juvenile, 10.7 mm, AMP33592; a, male, 10.4 mm, AMP33593.

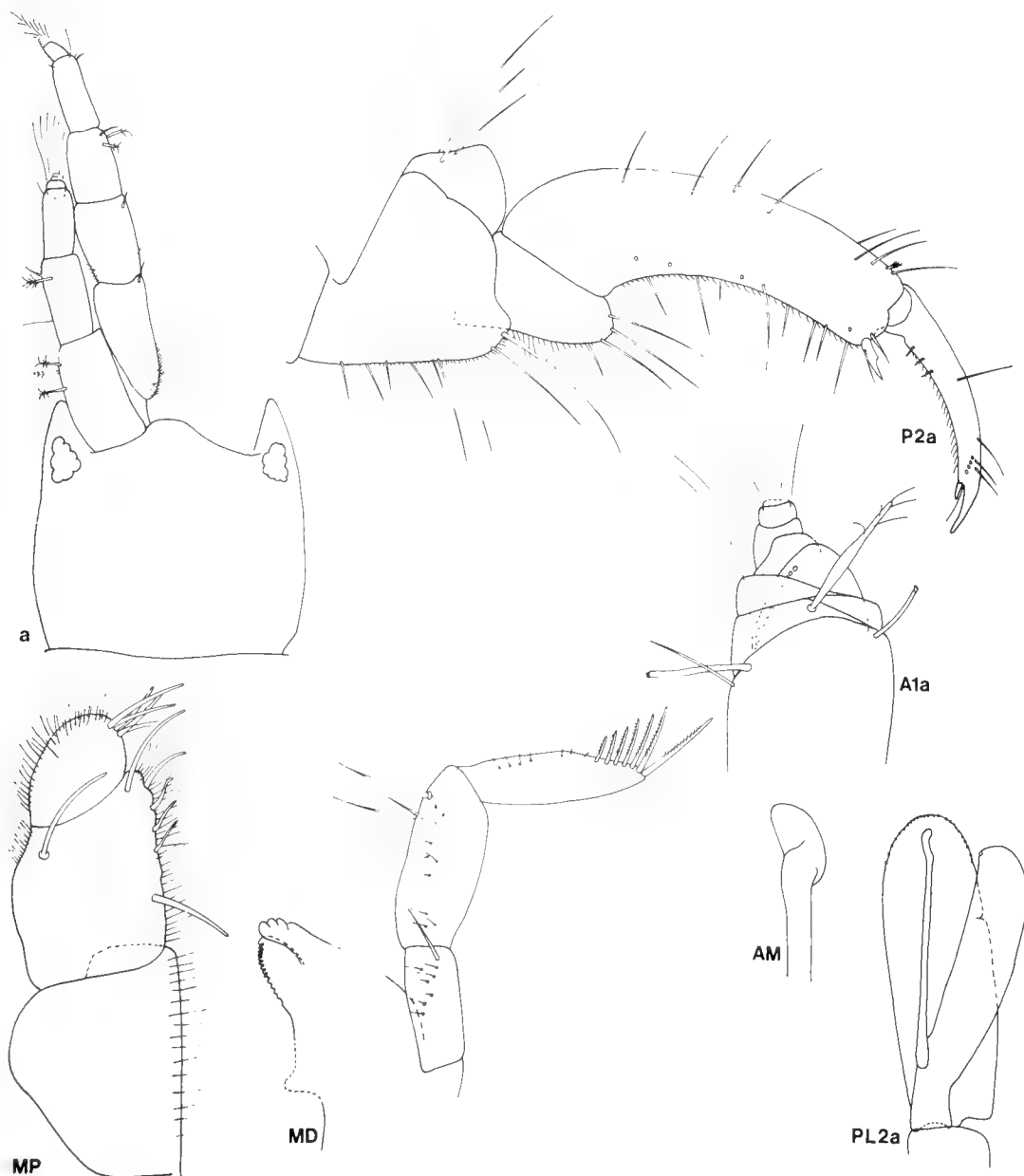


Figure 8. *Cyathura hakea*. Juvenile, 10.7 mm, AMP33592; a, male, 10.4 mm, AMP33593.

Powls, 1974, NMVJ2874(4). Hawkesbury River, AMHRS stations from 7 transects: AMP28609-12(4), AMP27958(10), AMP29760-6 (9), AMP29768-78(11). Narrabeen Lagoon, D. Dexter, AMP31004(1). Lane Cove River, AMP27937(1). Buffalo Creek, Lane

Cove River, B. W. Jenkins: 12 Sept 1978, AMP27957(1); 1 Apr 1979, AMP28602(7). Tuross River, AMESES station: AMP24941 (11). Wallaga Lake, AMESES stations: AMP24955-7(3). Merimbula, NSW SF stations: NMVJ2877(2), NMVJ2878(2).

Vic. Lake Barracoota, LVWSB station, 1 Nov 1980: NMVJ2888(5); Mallacoota Inlet, LVWSB station, 1978: NMVJ2870-3(9).

Description: Female. About $10\times$ as long as wide. Integument smooth, with numerous fine setae all over; shallow dorsal pits on pereonites 4-6. Head about as long as wide; rostrum shorter than lateral lobes, truncate. Antenna 1 reaching to end of article 4 of antenna 2; flagellum of 5 articles, with 3 terminal aesthetascs. Antenna 2 flagellum of several very short articles, one-third length of last article of peduncle.

Mandibular molar narrow, truncate; lamina dentata with 16 saw-teeth; incisor blunt. Palp articles 2 and 3 $1.5\times$ as long as article 1; all articles with fine hairs, first with 1 seta, second with 3 setae, third with a terminal comb of 7 spaced pectinate setae. Maxilliped covered with fine hairs; with a broad endite; article 3 with 4 mesial setae, 2 mesio-facial and 1 latero-facial; article 4 about half as long as 3, with 5 disto-mesial setae.

Pereopod 1 with a swollen but strongly tapering article 6; article 5 with a moderately acute posterodistal tooth; palm of article 6 axial, a prominent tooth midway along. Pereopods 2 and 3 posteriorly setose; article 5 posteriorly lobed; article 6 curved, only slightly more swollen than in posterior pereopods; article 7 with a secondary claw half as long as unguis.

Pereopods 4-7 increasing in length posteriorly, setose along posterior margin; pereopods 4-6 lack a secondary claw on dactyl. Pleopod 1 exopod operculiform, with about 50 marginal setae; endopod two-thirds length of exopod, without setae. Pleopod 2 rami equal in length; exopod with a partial suture, with about 30 setae; endopod with a single seta.

Pleon about as long as wide, as long as pereonite 7; pleonites 1-5 fused. Uropodal endopod reaching beyond end of telson, about as long as wide, wider proximally; exopod $2.3\times$ as long as wide, dorsal margin gently convex, distal apex obtusely rounded. Telson $2.5\times$ as long as wide, depressed, then distally upturned; densely covered with fine hairs dorsally, 3 pairs of dorsal setae distally, 3 pairs in an apical concavity.

Male: Differing from juvenile and female in antenna 1: flagellum of 5 articles, telescoping into terminal article of peduncle, and bearing numerous aesthetascs ventrally and distally. Pereopods all more elongate, pereopod 1 with a mesial row of 40 short setae. Pereopod 2 article 4 produced distolaterally along posterior margin. Pleopod 2 with appendix masculina reaching little beyond endopod.

Colour: Variable but lateral and mid-dorsal colour on pleon and dorsal pattern on head are most persistent elements. Dorsal pattern on pereon, ventral colour on antennae, head and some pereonites, laterally on proximal articles on pereopods 1-3.

Distribution: Southern-central NSW, eastern Victoria, estuaries and coastal freshwater lakes.

Etymology: *Hakea* is an endemic genus of Australian flowering plant, common in coastal south-eastern Australia.

Remarks: *Cyathura hakea* is superficially similar to *C. carinata* (from Europe) and *C. indica* (from the Indian Ocean) but available descriptions do not allow further useful comparisons.

Lake Barracoota, in which five specimens were taken, is a freshwater coastal dune lake only very rarely connected by flood water to Mallacoota Inlet. It is reasonable to assume that *Cyathura hakea* survives and reproduces in fresh water.

Acknowledgements

This contribution was made possible through a grant from the Australian Biological Resources Study. We are especially grateful to G. Milledge who inked all the figures. For the loan of material we are indebted to J. Lowry, A. Jones and P. Hutchings (Australian Museum, Sydney), P. Gibbs (NSW State Fisheries, Sydney), K. Robinson (University of NSW), D. Dexter (University of Sydney), P. Davie (Queensland Museum, Brisbane) and S. McCauley (LaTrobe Valley Water and Sewerage Board, Traralgon).

References

- AMANIEU, M., 1969. Variations saisonnières de la taille et cycle reproducteur à Arcachon de *Cyathura carinata*. *J. exp. mar. Biol. Ecol.* 4: 78-89.

- BARNARD, K. H., 1925. A revision of the family Anthuridae (Crustacea Isopoda), with remarks on certain morphological peculiarities. *J. Linn. Soc.* 36: 109-60.
- BOTOSANEANU, L. & STOCK, J. H., 1982. Les *Cyathura* stygobies (Isopoda, Anthuridea) et surtout celles des Grandes et des Petites Antilles. *Bijdr. Dierk.* 52: 13-42.
- BURBANCK, W. D., 1962. An ecological study of the distribution of the isopod *Cyathura polita* (Stimpson) from brackish waters of Cape Cod, Massachusetts. *Am. Midl. Nat.* 67: 449-76.
- BURBANCK, W. D. & BURBANCK, M. P., 1979. *Cyathura* (Arthropoda: Crustacea: Isopoda: Anthuridae). Chapter 9, pp. 293-323, in *Pollution Ecology of Estuarine Invertebrates* (Ed. C. W. Hart). Academic Press: London.
- NEGOUESCU, I. & WÄGELE, J. W., 1984. World list of the anthuridean isopods (Crustacea, Isopoda, Anthuridea). *Trav. Mus. Hist. nat. Gr. Antipa* 24: 99-146.
- NORMAN, A. M. & STEBBING, T. R. R., 1886. On the Crustacea Isopoda of the "Lightning", "Porcupine", and "Valorous" expeditions. *Trans. zool. Soc. Lond.* 12: 77-141.
- POORE, G. C. B., 1981. Paranthurid isopods (Crustacea, Isopoda, Anthuridea) from southeastern Australia. *Mem. natn. Mus. Vict.* 42: 57-88.
- POORE, G. C. B., 1984. *Paranthura* (Crustacea, Isopoda, Paranthuridae) from south-eastern Australia. *Mem. Mus. Vict.* 45: 33-69.
- TIMMS, B. V., 1973. A limnological survey of the freshwater coastal lakes of east Gippsland, Victoria. *Aust. J. mar. Freshwat. Res.* 24: 1-20.
- WÄGELE, J. W., 1979. Die Holonomie der Mundwerkzeuge von *Cyathura carinata* (Kröyer, 1847) (Crustacea, Isopoda, Anthuridea). *Zool. Anz.* 203: 334-41.
- WÄGELE, J. W., 1981. Zur Phylogenie der Anthuridea (Crustacea, Isopoda) mit Beiträgen zur Lebensweise, Morphologie, Anatomie und Taxonomie. *Zoologica, Stuttg.* 132: 1-127.
- WÄGELE, J. W., 1982. A new hypogean *Cyathura* from New Caledonia (Crustacea, Isopoda, Anthuridea). *Bull. zool. Mus. Univ. Amsterdam* 8: 189-97.
- WILLIAMS, W. D., 1980. "*Australian Freshwater Life*", Second edition. Macmillan: Melbourne. 321 pp.

APANTHURA, *APANTHURETTA* AND *APANTHUROPSIS* GEN. NOV.
(CRUSTACEA: ISOPODA: ANTHURIDAE) FROM SOUTH-EASTERN
AUSTRALIA

BY GARY C. B. POORE AND HELEN M. LEW TON

Department of Crustacea, Museum of Victoria, Russell Street, Melbourne, Victoria 3000, Australia

Abstract

Nine new species of *Apanthura* Stebbing (*A. banksia*, *A. callitris*, *A. drosera*, *A. isotoma*, *A. lambertia*, *A. mirbelia*, *A. styphelia*, *A. thryptomene* and *A. xanthorrhoea*), three new species of *Apanthuretta* Wägele (*A. correa*, *A. olearia* and *A. pimelia*) and *Apanthuropsis* *richea*, new genus and new species, are described, figured and keyed. Relationships between the three genera are discussed.

Introduction

Recently, numerous south-eastern Australian species of the family Paranthuridae have been described (Poore, 1978, 1981, 1984). This paper begins to address the larger related family, Anthuridae, and follows an earlier contribution on the genus *Haliophasma* (Poore, 1975). Poore (in the papers cited) has explained abbreviations and conventions used in the figures and the sources of material on which the study is based. In addition, samples from Port Hacking, New South Wales, have been made available by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Fisheries and Oceanography Division, Cronulla, NSW. Material collected during the 1970s from estuaries by the New South Wales State Fisheries (NSWSF) has also been included. Material from Bass Strait collected during the National Museum of Victoria's Bass Strait Survey (BSS stations) and from Cape Paterson, Vic. (CPA stations) contributed additional specimens.

Specific epithets for new species have been chosen from genera of the Australian flora and are used as nouns in apposition. This follows a pattern established for *Paranthura* (Poore, 1984).

Material is lodged in the Museum of Victoria, Melbourne (NMV), the Australian Museum, Sydney (AM), the Queensland Museum, Brisbane (QM), the South Australian Museum, Adelaide (SAM), the Tasmanian Museum and Art Gallery, Hobart (TM), and the Queen Victoria Museum, Launceston (QVM).

Apanthura*, *Apanthuretta* and *Apanthuropsis

The three genera included in this contribution share a 5-articled maxillipedal palp, fused pleonites, a long bean-shaped uropodal endopod and triangular or trapeziform fifth article on the walking legs (typical species in figure 1). They differ from the related genera *Cyathura* and *Mesanthura* in that the terminal article of the maxilliped is small and triangular and the uropodal endopod is longer.

The genus *Apanthura* historically has contained numerous species separated by only slight morphological differences (Kruczynski and Myers, 1976; Kensley, 1979). Wägele (1981a, b) was the first to attempt to divide the species when *Apanthuretta* was differentiated from *Apanthura*. The major character separating the two genera is structure of the pleon (pleonites 1-5 fused in *Apanthura*, pleonites 1-4 separated by dorsal folds in *Apanthuretta*). Wägele (1981a, b) maintained that species of *Apanthuretta* lack a maxillipedal endite. This is not so in Australian species nor in *A. magnifica* as Kensley's (1980) scanning electron micrograph demonstrates. Wägele (1981b) interpreted the endite in Kensley's and others' figures as a maxillar endite but both the maxilliped and maxilla of Australian species possess endites (e.g. fig. 30). Possession of maxillipedal endite, the presence of terminal setae on the telson, similar mandibular palp, and the elongate uropodal endopod suggest that the two genera are closely related.

Although pleonal structure is sometimes a character of doubtful value (e.g. in *Paranthura*,

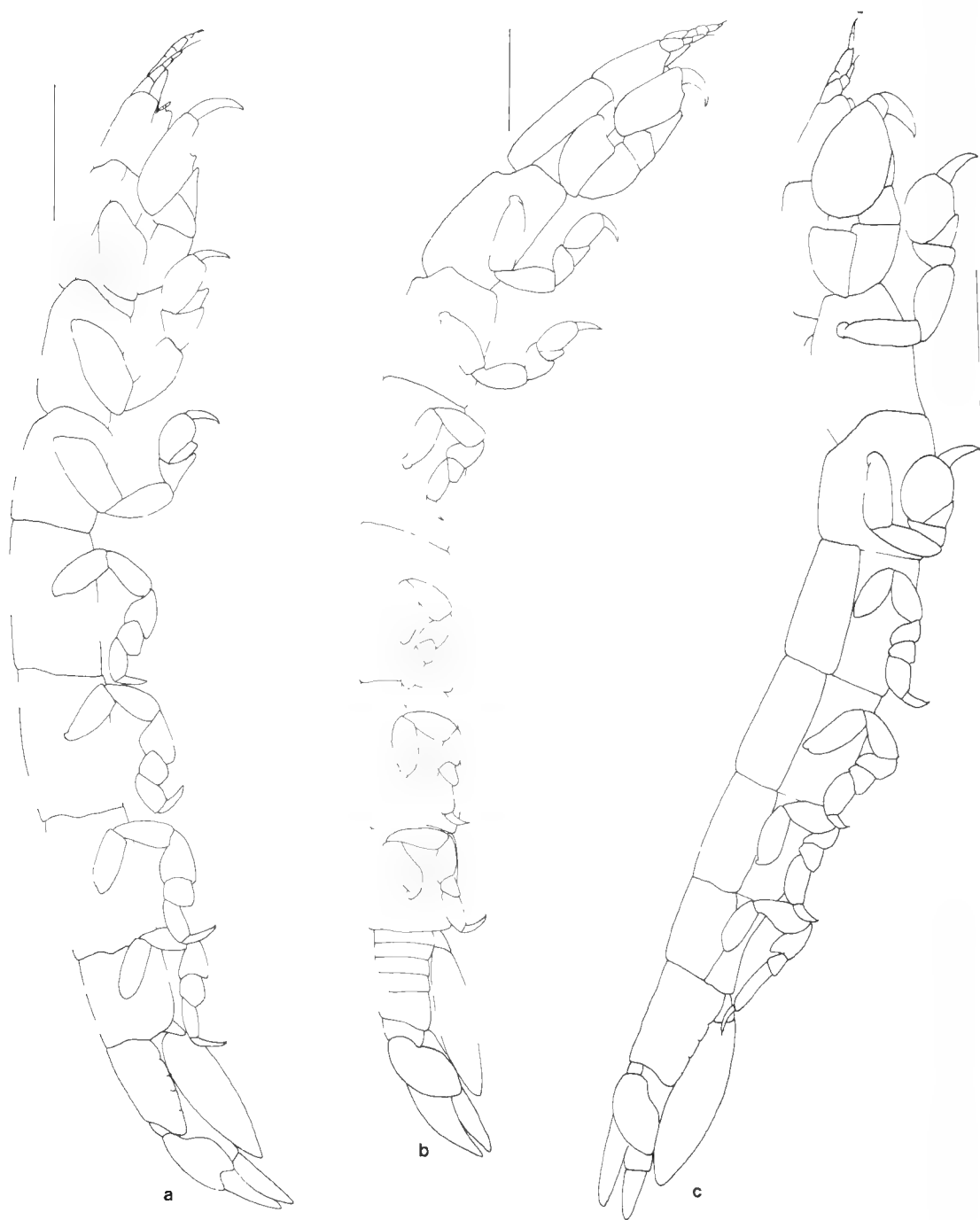


Figure 1. a, *Apanthura isotoma*, paratype juvenile, 9.0 mm, NMVJ2733; b, *Apanthuretta olearia*, paratype juvenile, 12.4 mm, NMVJ2231; c, *Apanthuropsis richea*, paratype juvenile, 7.4 mm, NMVJ2300. Scales = 1 mm. Pereopods are figured as if completely flat, not as normally held.

see Poore, 1984), in this case the reality of *Apanthuretta* is upheld by other character differences. The pleon is longer than wide in *Apanthuretta*, only as long as wide in *Apanthura*. The mesial setae of the palm of pereopod 1 of *Apanthuretta* are quite stout and articulate in shallow circular depressions (Kensley, 1980: fig. 1d); those on *Apanthura* are of more typical form. The cutting edge of this limb is definitely toothed in most species of *Apanthura*, but often only stepped in species of *Apanthuretta*. Males of *Apanthuretta* possess a flagellum on antenna 1 of more than ten articles; in *Apanthura* ten or fewer are found.

Examination of descriptions of *Apanthura* in the literature reveals several apparent conflicts which question the separation of the two genera. Kensley (1980) pointed out that the pleonites of *A. magnifica* Menzies & Frankenberg were fused (meaning that these segments do not articulate) but that dorsal integumental folds separate pleonites 1-4. His SEMs clearly differentiate these folds from true sutures. We suspect that some so-called species of *Apanthura* figured without these dorsal folds may in fact possess them (e.g., *A. mana* Kensley, *A. motasi* Negouescu, *A. libyana* Negouescu). We are inclined to place these species in *Apanthuretta* on the basis of elongate pleon and elongate male antenna 1. *Apanthura californiensis* Schultz was originally figured with six free pleonites. Specimens seen by us confirm that there is in fact no fold between pleonites 4 and 5 and the species belongs, probably with *A. inornata* Miller & Menzies, in *Apanthuretta*.

Typically pleonites of *Apanthura* are fused, sutures between them are visible only ventrolaterally. In one Australian species, *A. mirbelia*, the sutures are apparent dorsally but do not meet in the middle. Two Mediterranean species, *A. corsica* Amar and *A. tyrrhenica* Wägele, are figured with separate pleonites (Wägele, 1980) but in all other respects the two are typical of *Apanthura*.

Two species-groups are apparent among Australian *Apanthura* (s.s.). These are not given formal rank here because one intermediate species was found and because descriptions of species from elsewhere do not

allow them to be assigned to group with confidence.

Species of the first group have a single minute seta on the second article of antenna 1 and a single long seta on the third (in addition to 3-4 dorsal terminal setae); there are no long lateral setae on the first article. Species of the second group possess at least six long lateral setae on the second article of antenna 1 and at least two on the third article; long setae may be present on the first article. The marginal setal row on the uropodal endopod is continuous in species-group 1 but is broken in species-group 2, with three brush-setae in the hiatus. The apex of the telson tends to be more acute in species-group 2 than in species-group 1. Finally, pereopods 4-7 of species of group 1 possess fourth and fifth articles with short anterior margins and barely convex posterior margins. In species-group 2 these articles have longer anterior margins and lobed setose posterior margins.

The type-species, *Apanthura sandalensis* Stebbing, of which the holotype was examined, has all the features of species-group 1. The Australian species with affinities to both groups is *A. banksia*.

The new genus *Apanthuopsis* shares with *Apanthura* and *Apanthuretta* a maxilliped with five articles, similar pereopod 1 and pereopods 4-7 and antennae. However numerous differences suggest that the similarity may not be more than superficial. Only a single species is known.

Key to south-eastern Australian species of *Apanthura*, *Apanthuretta* and *Apanthuopsis*

Every effort has been made to avoid qualitative comparisons in this key but this has not always been possible; the user is advised to refer to the figures when in doubt.

1. Pereopods 2 and 3 with sixth article similar to that of pereopod 1, ovoid; maxilliped without endite, article 3 longer than wide; mandibles asymmetrical, molars fitting as tooth and socket *Apanthuopsis* (monotypic *A. richea*, figs. 34-37)
- Pereopods 2 and 3 with sixth article different from that of pereopod 1, elongate; maxilliped with endite, article 3

- wider than long or barely longer than wide; mandibles symmetrical, molars with flat opposing surfaces 2
2. Pleonites 1-5 fused (rarely apparently separated by dorsal folds); pleon about as long as pereonite 7; male antenna 1 flagellum of about 10 articles *Apanthura* 3
- Pleonites 4-5 only fused; pleon longer than pereonite 7; male antenna 1 flagellum of about 20 articles *Apanthuretta* 11
3. Antenna 1 bearing a single minute seta laterally on article 2 (in addition to brush-setae); pereopods 2-7 without strong lobes on articles 4 and 5, only moderately setose; dorsal lobe of uropodal exopod reaching as far posteriorly as ventral lobe 4
- Antenna 1 bearing at least 6 long setae laterally on article 2 (in addition to brush-setae); (not more than 3 long setae in *A. banksia*); pereopods 2-7 with setose lobes on articles 4 and 5; dorsal lobe of uropodal exopod not reaching as far posteriorly as ventral lobe 8
4. Pleonal sutures visible only dorsolaterally; apex of telson broadly rounded; male pereopod 1 without a palmar tooth, article 5 grossly and complexly expanded distoposteriorly *Apanthura mirbelia* (figs. 15-17)
- Pleonal sutures not visible dorsally; apex of telson narrowly rounded; male pereopod 1 with palmar tooth, article 5 only slightly expanded 5
5. Integument pigmented; telson $2.5\times$ as long as wide; pereopod 1 palm oblique with a well-developed conical tooth; male with a large ventral swelling at base of maxillipeds; male pereopod 1 with a strong tooth on article 5 *Apanthura xanthorrhoea* (figs. 23, 24)
- Integument not pigmented; telson less than $2\times$ as long as wide (rarely more than $2\times$); pereopod 1 palm axial and with a small tooth; male with a poorly-developed ventral chin, or none; male pereopod 1 with tooth on article 5 similar to juvenile 6
6. Telson with numerous lateral setae on distal third; head with a prominent ventral lobe at base of maxillipeds *Apanthura thryptomene* (figs. 20-22)
- Telson with 1-2 pairs of lateral setae about $3/4$ way along; head without a ventral lobe 7
7. Telson less than $2\times$ as long as greatest width; male pereopod 1 with a conical tooth on palm distal to midpoint *Apanthura styphelia* (figs. 18, 19)
- Telson $2.3\times$ as long as greatest width; (male not known) *Apanthura drosera* (figs. 7, 8)
8. Uropodal endopod having a complete distolateral marginal setal row; telson apically rounded and with few dorsal setae; antenna 1 article 2 with 1-3 lateral setae *Apanthura banksia* (figs. 2, 3)
- Uropodal endopod having rows of distal and lateral marginal setae separated by a distinct hiatus; telson tapering apically (or, if rounded, with pairs of dorsal setae); antenna 1 article 2 with at least 6 lateral setae 9
9. Telson having lateral margins convex, dorsal setae in pairs near midline; male pereopod 1 with a palmar tooth *Apanthura callitris* (figs. 4-6)
- Telson having lateral margins straight or concave distally, dorsal setae near margin; male pereopod 1 without a palmar tooth 10
10. Telson tapering from proximal third; male pereopod 2 with a truncate blade on the palm and a setose triangular article 5; pereonite 1 of male without a ventral keel *Apanthura lambertia* (figs. 12-14)
- Telson tapering only on distal third; male pereopod 2 with a straight palm and a strong truncate lobe on article 5; pereonite 1 of male with a ventral keel *Apanthura isotoma* (figs. 9-11)
11. Antenna 1, first 2 articles each with at least 2 lateral long setae; uropodal endopod elongate (about $2\times$ as long as broad *Apanthuretta pimelia* (figs. 31-33)
- Antenna 1, first article without lateral setae, second with at most 1 long seta; uropodal endopod compact (about $1.5\times$ as long as broad) 12
12. Telson with evenly convex lateral margins and rounded apex, a single pair of long

- dorsal setae; uropodal exopod widest distally, its posterior apex short and acute; male without a developed chin *Apanthuretta olearia* (figs. 28-30)
- Telson tapering distally to a narrowly rounded apex, with 2 pairs of long dorsal setae; uropodal exopod widest at midpoint, its posterior apex long and rounded; male with a well-pronounced chin *Apanthuretta correa* (figs. 26-27)

***Apanthura* Stebbing**

Apanthura Stebbing, 1900: 621.—Barnard, 1925: 141.—Kruczynski & Myers, 1976: 354ff.—Wägele, 1981b: 116 (major references only).

Diagnosis: Integument smooth, sometimes pigmented. Eyes present, rarely absent. Antenna 1 flagellum short, of 3 articles, the last minute and bearing 3 aesthetascs. Antenna 2 flagellum short, 2-4 articles. Mandibles symmetrical, not sexually dimorphic; incisor, lamina dentata and blunt molar present; palp 3-articled, article 3 one-third length of article 2, with 3-4 terminal setae. Maxilliped of five articles and bearing an acute endite with terminal seta; article 3 wider than long; article 4 usually with a row of mesial setae; article 5 oblique, subterminal, much smaller than 4, with 4-6 apical setae.

Pereopod 1 subchelate, article 6 swollen, palm usually with a tooth, mesial setae not especially stout. Pereopods 2 and 3 with article 6 only little more robust than posterior pereopods. Pereopods 4-7 with article 5 triangular-trapeziform, sometimes strongly lobed posteriorly, its anterior margin free.

Pleon short (about as long as pereonite 7), as long as wide; typically pleonites 1-5 fused dorsally (rarely free); pleonite 6 free from others and from telson. Pleopod 1 exopod operculiform, endopod setose; pleopods 2-5 setose. Uropodal endopod as long as peduncle, marginal lateral setal row either continuous or with a distolateral hiatus; exopod broad, excavate distally at least to the extent that there is a definite dorsodistal lobe. Telson with two basal statocysts, dorsal surface and apex with long setae.

Male antenna 1 flagellum with about 10 isometric articles bearing numerous aesthetascs; as long as head.

Type-species: *Apanthura sandalensis* Stebbing, 1900 (Holotype in BMNH).

Remarks: *Apanthura* in Australia is confined to species in which there are no complete dorsal folds between the pleonites. As has been noted previously (Kensley, 1979) species of *Apanthura* are separated on only subtle morphological differences which are often difficult to quantify. Appreciation of the two species-groups defined above aids in species recognition and, we hope, will encourage authors to describe species in greater detail in future.

As is true in *Apanthuretta* and *Paranthura* (Poore, 1984) the recognition of males is extremely helpful in definition of species.

***Apanthura banksia* sp. nov.**

Figures 2, 3

Material examined: 5 juveniles, 6.9-11.9 mm:

Holotype: juvenile, 11.9 mm AMP32626 (with one slide). NSW, Jervis Bay (35°03'S., 150°44'E.), NSWSF stn 54, 1972.

Paratypes: NSW, type locality, NMVJ3184 (1 specimen). NSW, Lord Howe Island, rocks off Signal Point, lagoon, eel grass on coarse shelly sand, 1.5 m, J. K. Lowry, 9 May 1977 (stn LHA-1), AMP29806(1). Lord Howe Island, North Bay, *Zostera* on sand, J. K. Lowry and G. D. Fenwick, 12 May 1977, AMP29808(2).

Description: Integument not pigmented. Eyes present. Head 1.2× as long as wide, barely tapering anteriorly. Antenna 1 peduncle with 1-3 and 1 long marginal setae on articles 2 and 3 respectively. Maxilliped article 4 with 4 mesial setae, 1 laterally and 2 distally; article 5 with 5 setae, not exceeding distal margin of article 4.

Pereopod 1 article 4 with 7 mesial setae on anterior margin; article 5 with 7 mesial setae, with a pronounced distal tooth; article 6 palm with a pronounced tooth distal to midpoint, 11 marginal setae and 17 setae on mesial face. Pereopod 2 article 4 with 3 anterior setae, with a setose posterior margin not produced distally; article 5 well produced distally into a blunt setose lobe; article 6 ovoid, mesially setose, without long marginal setae. Pereopod 3

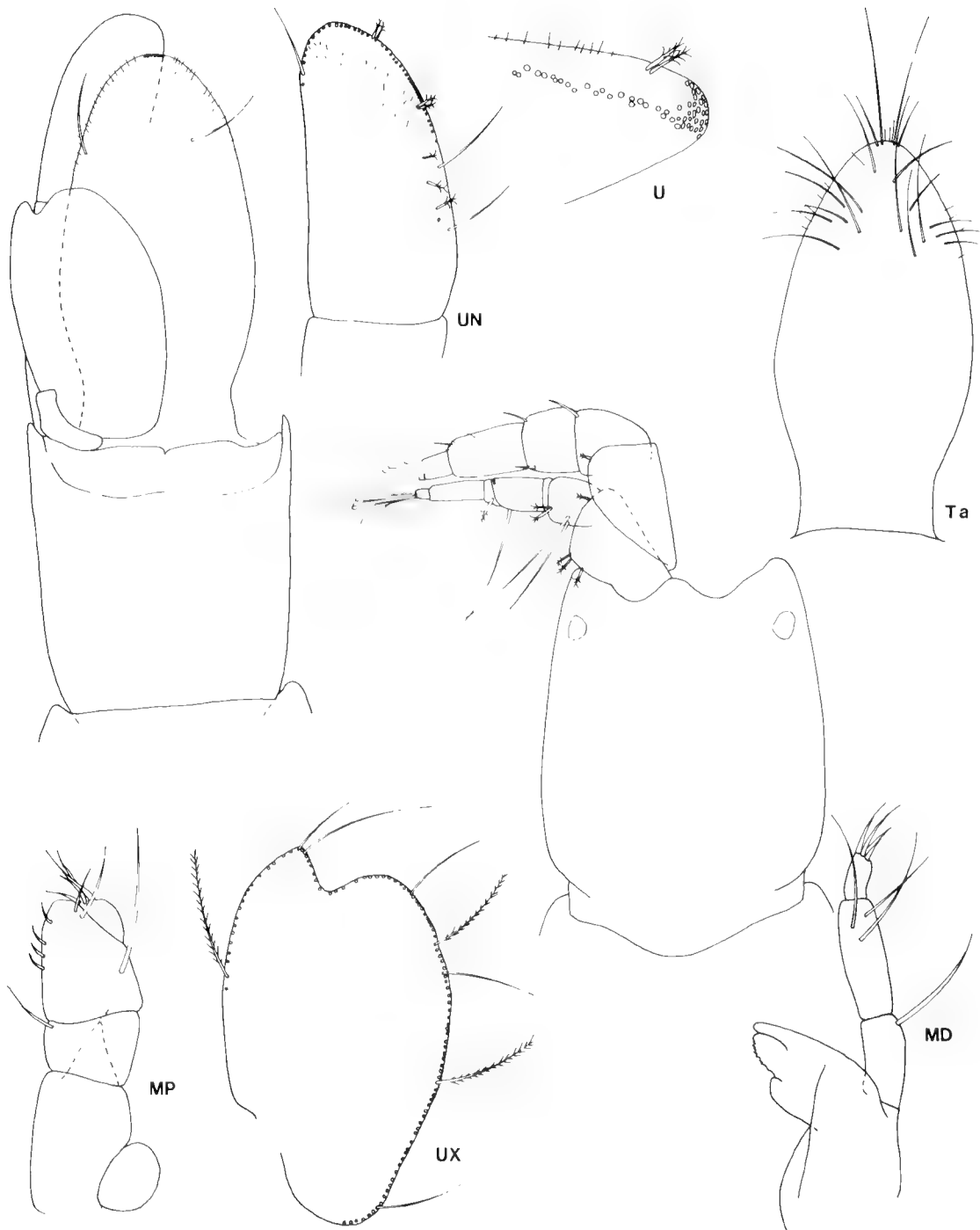


Figure 2. *Apanthura banksia*. Holotype juvenile, 11.9 mm; a, juvenile, 7.6 mm, AMP29809.

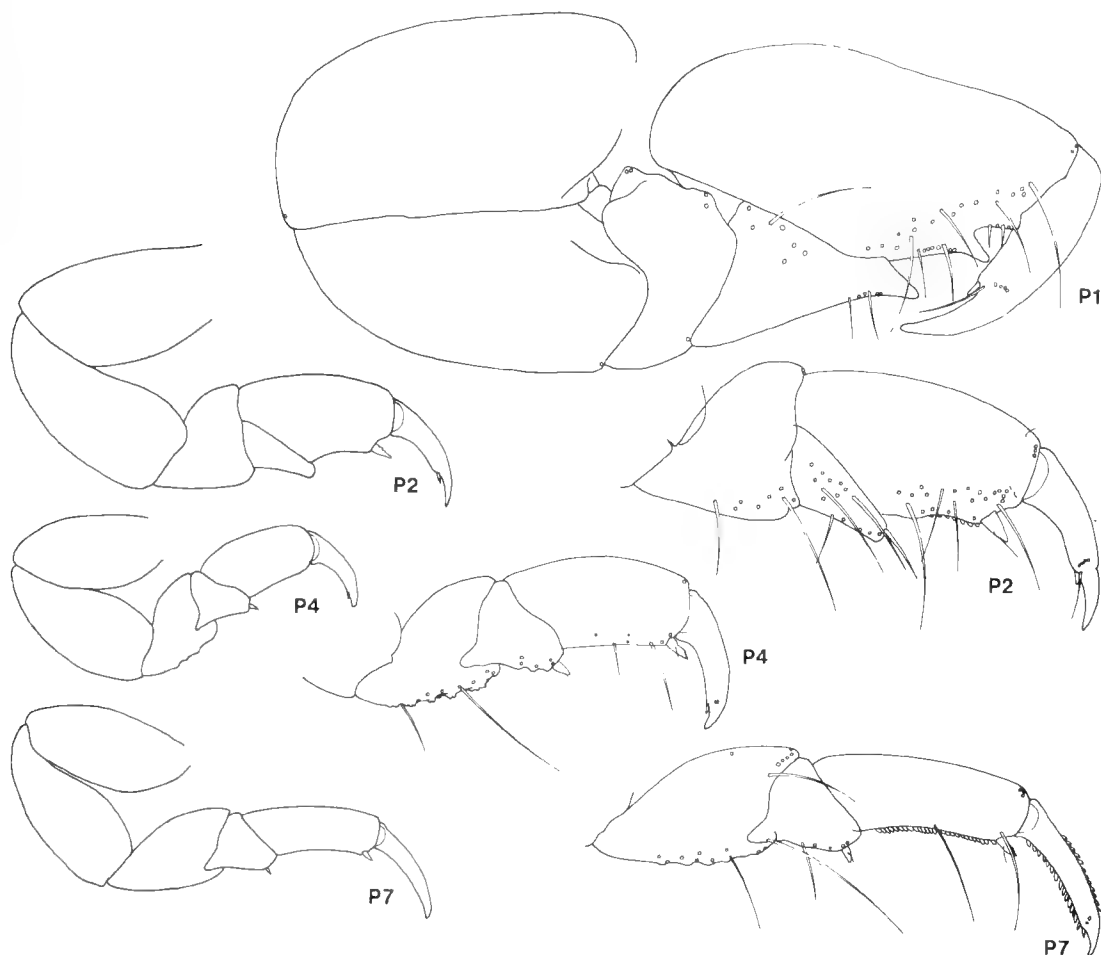


Figure 3. *Apanthura banksia*. Holotype juvenile, 11.9 mm.

similar to 2, but smaller. Pereopods 4-7 with articles 4 and 5 with convex posterior margins bearing few long setae.

Uropodal endopod with a continuous row of long setae just ventral to lateral margin, and terminally; 2 brush-setae just ventral to lateral margin, and 5 others dorsally. Exopod $1.7\times$ as long as greatest width, ventral distal lobe acutely rounded and separated from the broadly rounded dorsal lobe by an acute angular notch. Telson $1.5\times$ as long as pleon, $2.0\times$ as long as greatest width, lateral margins evenly curved and with a broadly rounded apex; dorsal setae only on distal third.

Male: Unknown.

Distribution: New South Wales including Lord Howe Island, sandy sediments.

Remarks: *Apanthura banksia* shares features of both species groups into which all other Australian species of the genus can be divided. Its affinities with species-group 1 are: a continuous marginal setal row on the uropodal endopod (except that this is more ventral with respect to the brush-setae than is typical); and a rounded telsonic apex. The species shares with those in species-group 2: long setae on the second article of antenna 1 (only 1-3 rather than six or more which is typical); and moderately developed lobes on the walking legs.

The antenna 1 and setose telson serve to distinguish the species from other Australian species of *Apanthura*.

The specimens from Lord Howe Island are smaller (6.9-7.6 mm) and possess a more setose telson than those from the NSW mainland. However, none was mature and no other differences could be found.

***Apanthura callitris* sp. nov.**

Figures 4-6

Material examined: 10 males, 329 juveniles; 4.6-12.4 mm:

Holotype: juvenile, 8.3 mm, QMW10017 (with one slide). Qld, Moreton Bay, Middle Banks, W. of Tangalooma, S. Cook and S. Newlands (QUBS station), Mar 1974.

Paratypes: Qld, type locality, QMW10018(1), QMW10019 (1 male), QMW10020 (1 male), QMW4728(14), NMVJ2906(20), AMP33584 (10). Type locality, June 1973, NMVJ2907 (2 males, 10 juveniles); Sep 1972, NMVJ2913 (1 male, 3 juveniles), J2914(1); Dec 1972, NMVJ2915 (1 male).

Other material: Qld, type locality, Dec 1972-March 1974: 273 specimens from 13 QUBS stations, QMW4721-5, W4728, W4734, W6129, W8385, W8456, W8459, W8462, W8463.

Description: Integument not pigmented. Eyes present. Head $1.3\times$ as long as wide, tapering anteriorly. Antenna 1 peduncle with 7 and 4 long marginal setae on articles 2 and 3 respectively (none on first article) and with marginal brush-setae on articles 1 and 2. Mandibular palp articles with 1, 4 and 3 setae respectively. Maxilliped article 4 with 4 mesial setae, 1 laterally and 2 distally; article 5 with 6 setae, barely exceeding distal margin of article 4; surface of article 4 with fine hairs.

Pereopod 1 article 4 with 12 mesial setae along anterior margin; article 5 with 6 mesial setae, with a pronounced distal tooth; article 6 palm with pronounced tooth at midpoint, 2 marginal rows each of 6 setae, with a setose posterior lobe produced distally to shield article 5; article 5 well produced distally into a sharp setose lobe; article 6 linear-ovoid, mesially setose and with setae only along posterior

margin. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with articles 4-5 having lobed posterior margins bearing numerous long setae.

Uropodal endopod with a discontinuous row of long setae along lateral and terminal margin; 3 brush-setae in hiatus of setal row and others dorsally. Exopod $2.0\times$ as long as greatest width, distal lobes well separated by an angular notch at the end of an almost straight dorsal margin. Telson as long as pleon, $1.9\times$ as long as greatest width, lateral margins strongly convex and tapering to broadly triangular apex; not strongly convex in longitudinal section; 3 pairs of dorsal setae near midline on distal third.

Male: Antenna 1 with flagellum of 10 articles, reaching to posterior margin of head. Eyes enlarged. Pereopod 1 with article 5 more elongate and tooth more projecting than in juvenile; article 6 more swollen, mesial setae on palm more numerous; article 7 with a blade along posterior margin. Pereopods 2 and 3 article 5 with a strongly produced, narrow posterior lobe. Most posterior pereopods slightly more elongate than in juvenile. Pleon more elongate than in juvenile. Appendix masculina on pleopod 2 a simple rod not reaching to end of endopod.

Distribution: Queensland, Moreton Bay; sandy sediments.

Remarks: *Apanthura callitris* is a typical member of *Apanthura* species-group 2. The species co-occurs with *A. lambertia*, both in high densities, in Moreton Bay, Qld, but is easily distinguished by its broad rounded telson. The anterior pereopods of males are not as highly modified as in other species in this species-group.

***Apanthura drosera* sp. nov.**

Figures 7, 8

Material examined: 4 juveniles; 5.7-7.3 mm.

Holotype: juvenile, 6.5 mm, NMVJ4160 (with one slide). Bass Strait, eastern Bass Strait ($39^{\circ}05.8'S.$, $147^{\circ}26.2'E.$), coarse shell, 59 m, 18 Nov 1981 (BSS stn 175).

Paratypes: Bass Strait, $39^{\circ}06.7'S.$, $143^{\circ}07.4'E.$ (BSS stn 192), NMVJ4162(1); $39^{\circ}38.2'S.$,

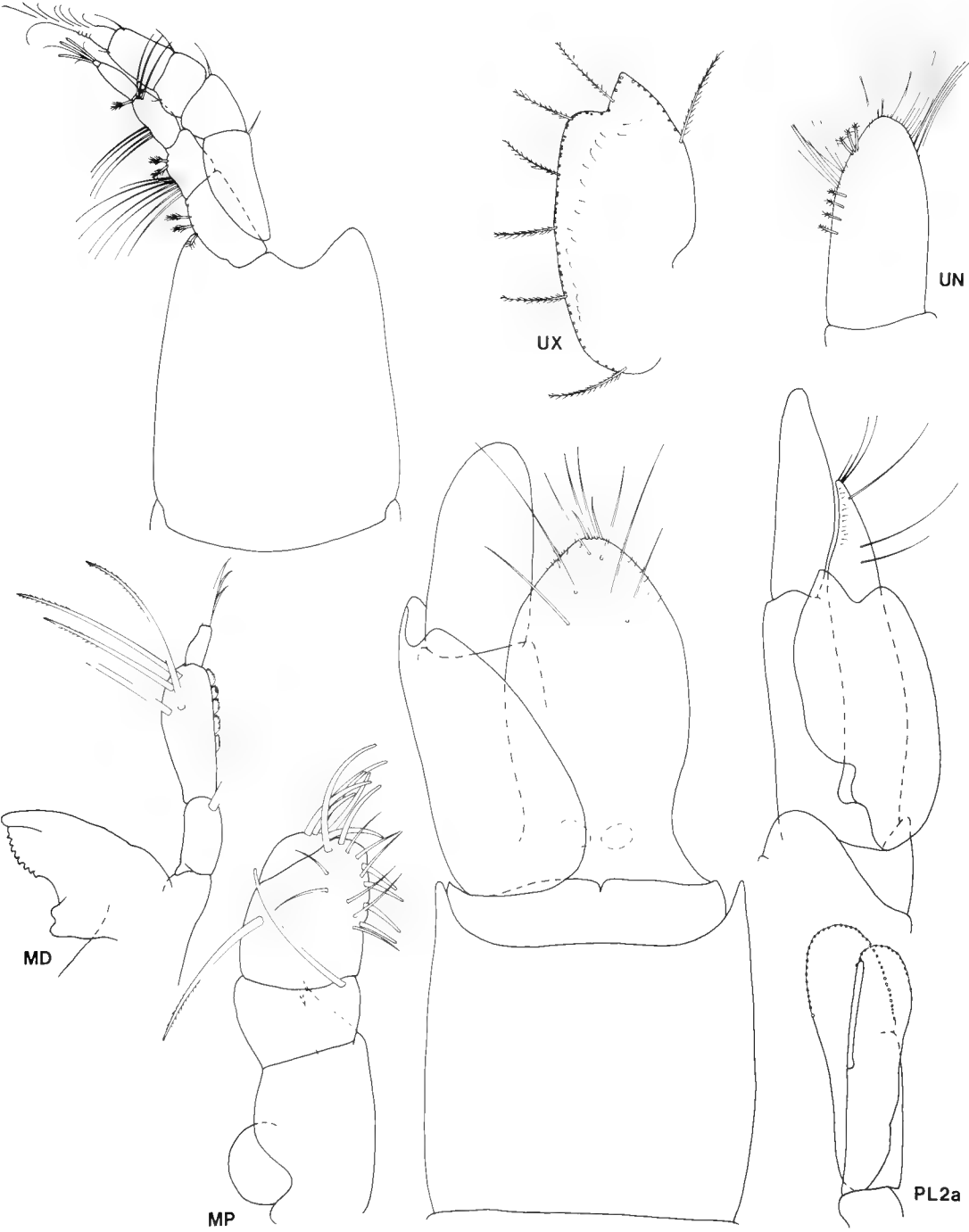


Figure 4. *Apanthura callitris*. Holotype juvenile, 8.3 mm; a, paratype, male, 12.4 mm, QMW10019.

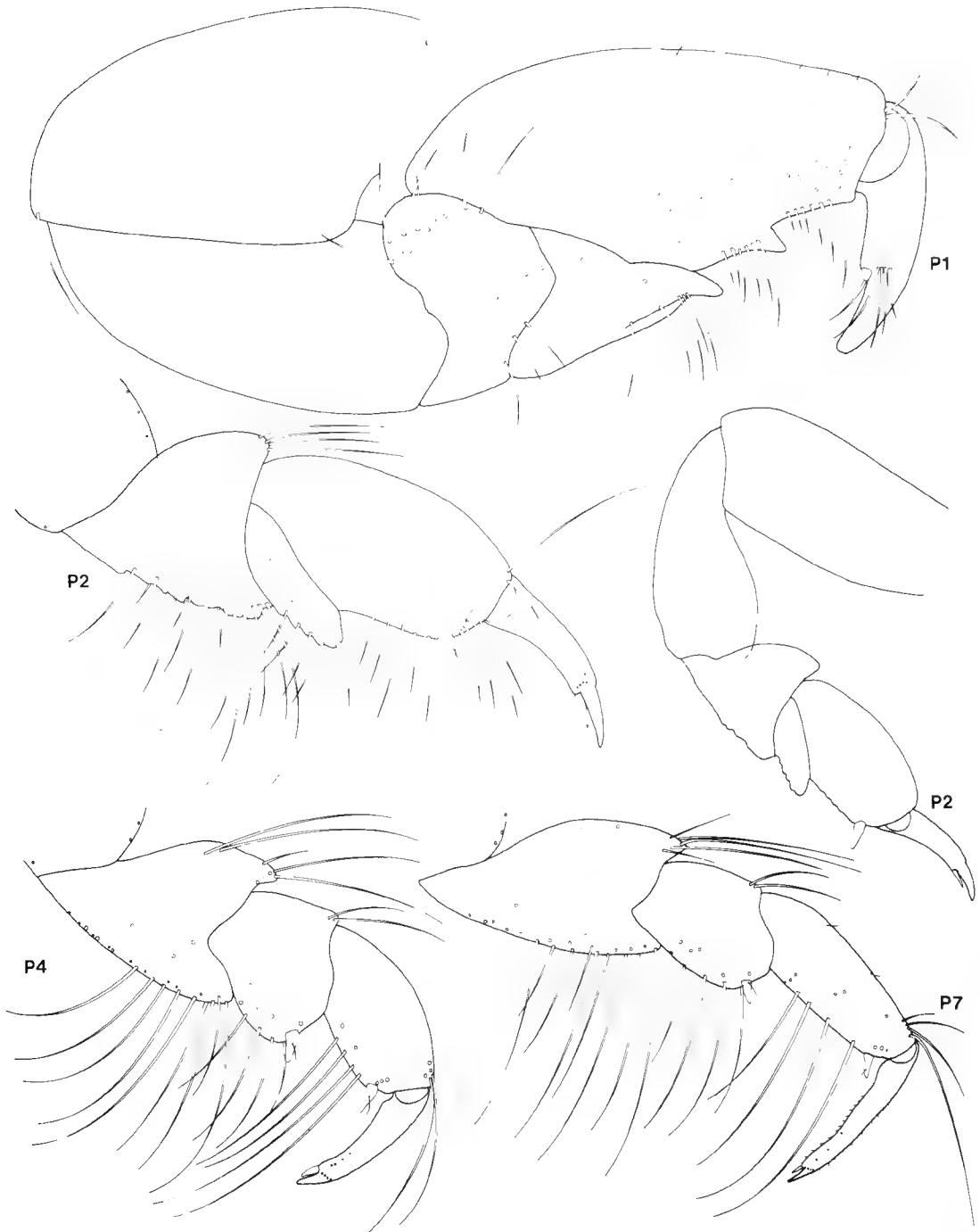


Figure 5. *Apanthura callitris*. Holotype juvenile, 8.3 mm.

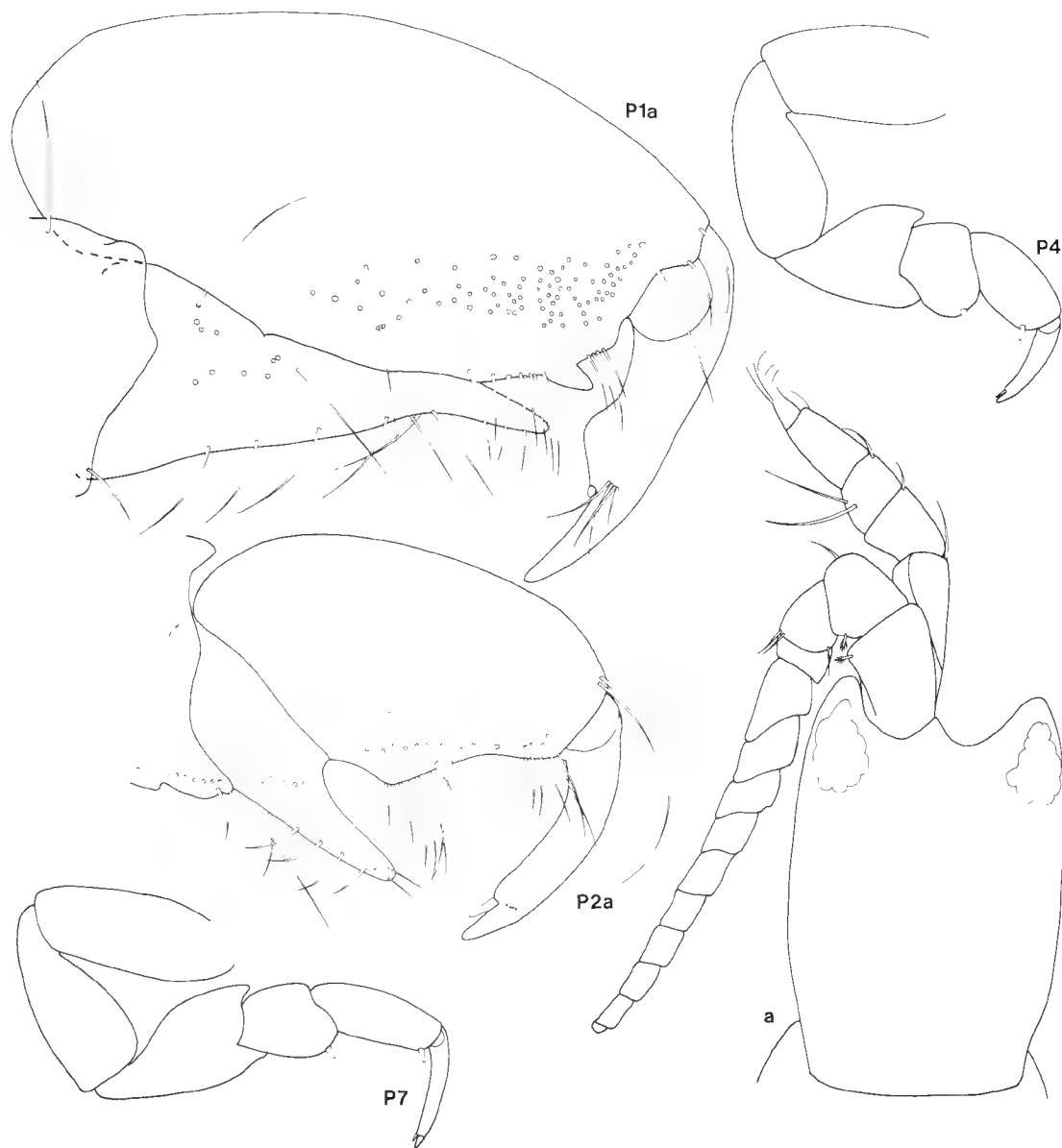


Figure 6. *Apanthura callitris*. Holotype juvenile, 8.3 mm; a, paratype male, 12.4 mm, QMW10019.

143°07.2'E. (BSS stn 195), NMVJ4163, J4164, (2).

Description: Integument not pigmented. Without pigmented eyes. Head $1.2\times$ as long as wide, tapering anteriorly. Antenna 1 peduncle with 1 long marginal seta on article 3, 1 short marginal seta and marginal brush-setae on both articles 1 and 2. Mandibular palp articles with

1, 1 and 3 setae respectively. Maxilliped article 4 with 2 mesial setae, 1 laterally and 2 distally; article 5 with 5 setae, reaching level with end of article 4; surface with few fine hairs.

Pereopod 1 article 4 with 1 mesial seta on anterior margin; article 5 with pronounced distal tooth; article 6 palm with pronounced tooth at midpoint, 9 marginal setae and few

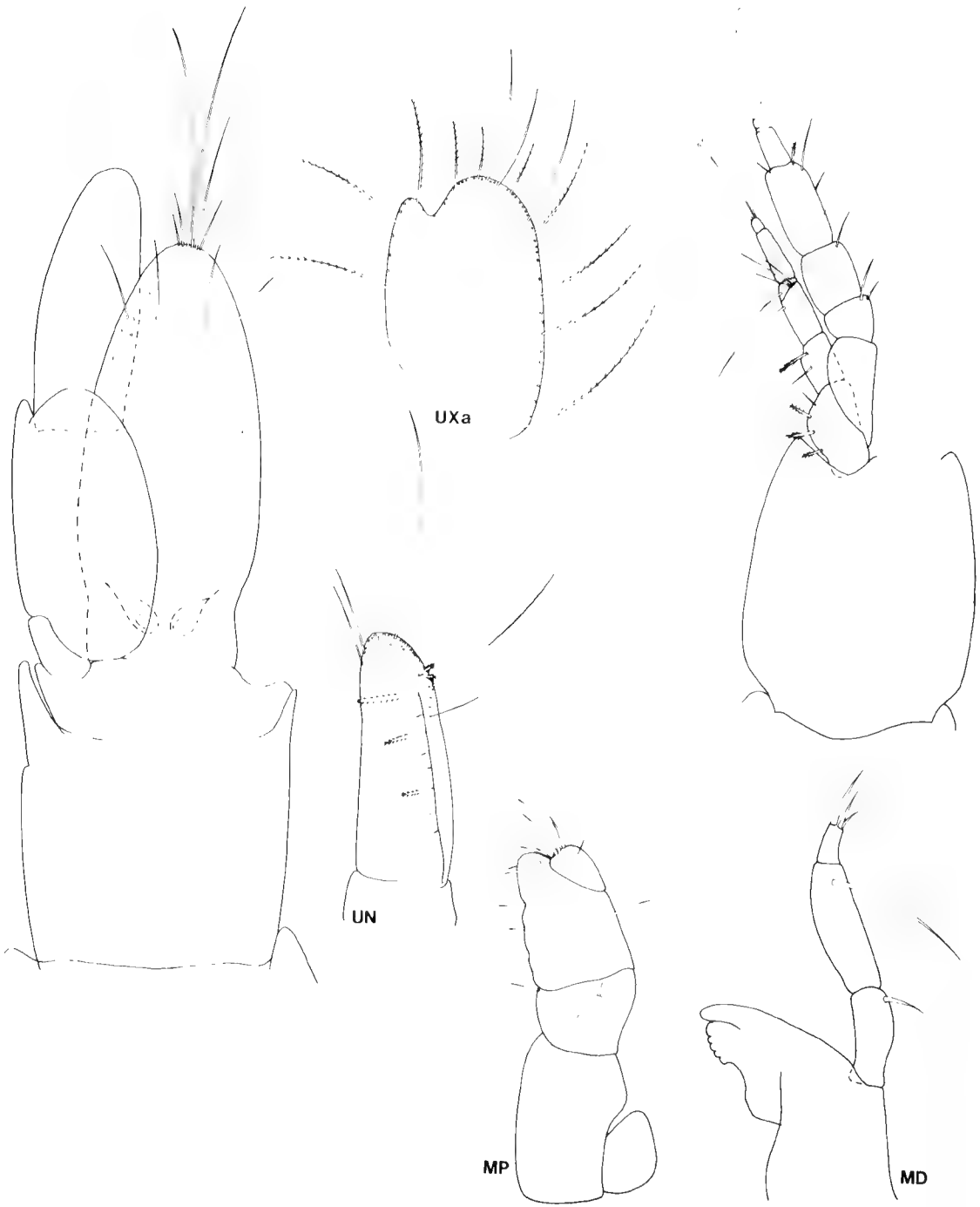


Figure 7. *Apanthura drosera*. Holotype juvenile, 6.5 mm; a, paratype juvenile, 6.2 mm, NMVJ4162.

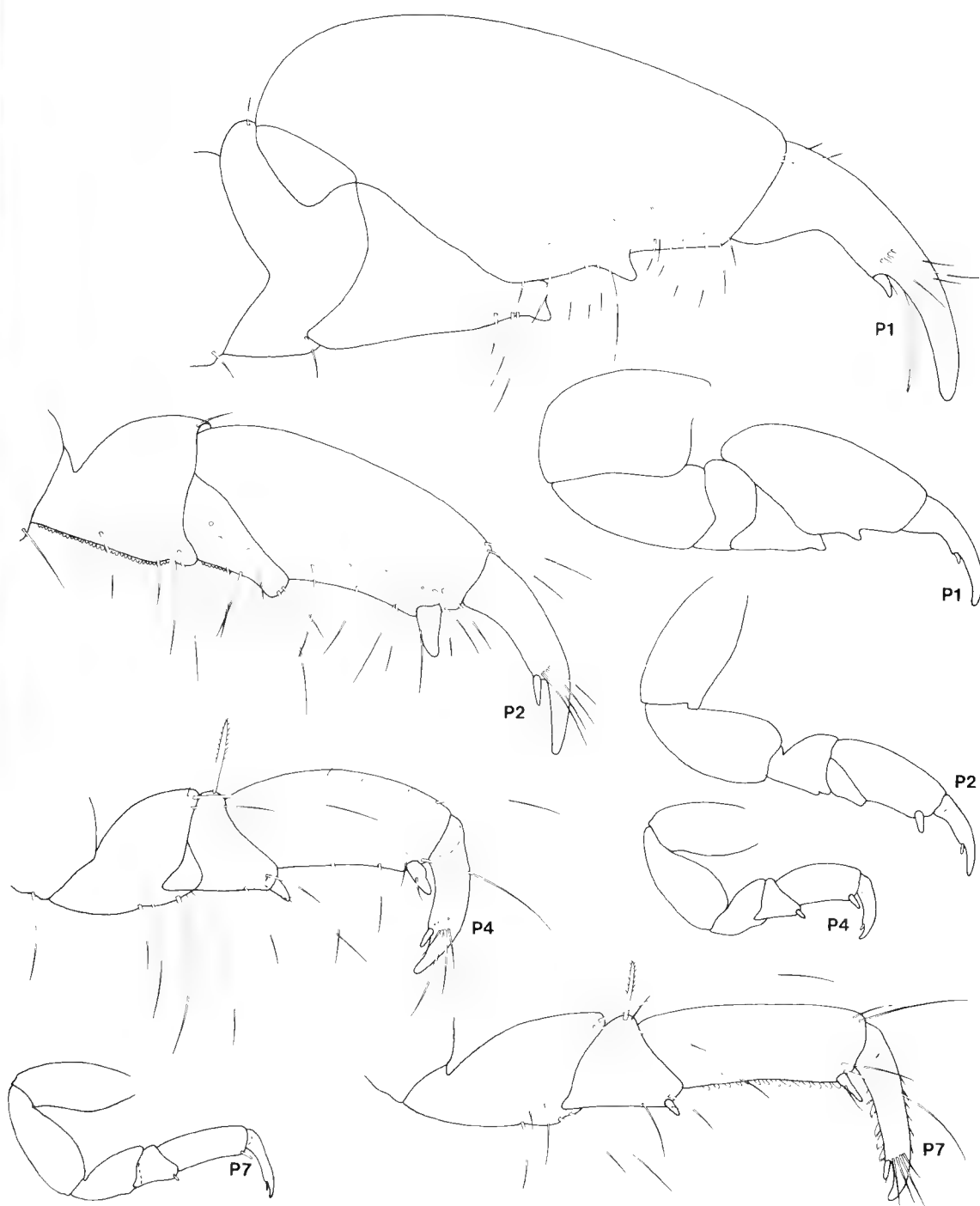


Figure 8. *Apanthura drosera*. Holotype juvenile, 6.5 mm.

setae on mesial face. Pereopod 2 article 4 with 1 anterior seta, its posterior margin not produced distally; article 5 barely produced distally into a blunt lobe; article 6 linear-ovoid, with few mesial setae and no setae on anterior margin. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with only article 5 distally lobed.

Uropodal endopod with a continuous row of long setae along lateral and terminal margin; 2 brush-setae on distolateral margin and 3 others dorsally. Exopod $1.7\times$ as long as greatest width, ventral distal lobe acute and separated from the much larger rounded dorsal lobe by an acute angular notch. Telson $1.3\times$ as long as pleon, $2.3\times$ as long as greatest width, widest at proximal one-third and tapering sharply to a narrowly rounded apex; 2 pairs of dorsal setae near apex, few marginal dorsal setae.

Male: Unknown.

Distribution: Bass Strait, 59-127 m, shelly substrates.

Remarks: *Apanthura drosera*, a typical member of species-group 1, is similar to *A. styphelia*, particularly in that both possess relatively long antennae. The distinguishing feature of this species is, however, the narrower tapering telson and narrow uropodal endopod. *Apanthura drosera* is known only from shelly sediments in Bass Strait whereas *A. styphelia* is confined to coastal bays.

***Apanthura isotoma* sp. nov.**

Figures 1a, 9-11

Material examined: 1 male, 106 juveniles; 4.3-12.5 mm;

Holotype: juvenile, 10.5 mm, NMVJ1486 (with one slide). Vic., Port Phillip Bay, off Rosebud ($38^{\circ}21.0'S$, $144^{\circ}55.0'E$), sand, 4 m, 12 Oct 1971 (PPBES stn 986).

Paratypes: Vic., type locality NMVJ1487 (1 specimen), NMVJ1488(9), NMVJ1490(1), NMVJ1419(1). Port Phillip Bay, PPBES stations: stn 968, NMVJ2729(3); stn 973, NMVJ1489 (1 male), J1492(4); stn 979, NMVJ2730(1). Port Phillip Bay, off Patterson R.: AMP33581(38), NMVJ2731(4), NMVJ2732(5), NMVJ2733(8), NMVJ2734(2), NMVJ2735(11).

Other material: Vic., Black Rock, Breamlea,

very fine sand, 15 m, J. Dorsey, 24 Jan 1979 NMVJ2922(1). Off McGaurans Beach (near Seaspray), fine sand, 9 m, J. E. Watson, 1981, NMVJ2923(2), NMVJ3434(1).

Tas., Lagoon Bay, sand, 16 m, A. J. Dartnall, 7 June 1977, TMG2645(8). Schouten Passage, sand, 12 m, A. J. Dartnall, 8 Jan 1979, TMG2647(2). Off Little Swanport, sand, 10 m, A. J. Dartnall, 8 June 1977, TMG2646(1).

NSW, E. of Burwood Beach ($32^{\circ}57.3'S$, $151^{\circ}44.4'E$), sand, 14 m, 10 June 1975 (HDWBS station), AMP24040(1). Botany Bay, AMP33582(1).

Description: Integument not pigmented. Eyes present. Head $1.2\times$ as long as wide, tapering anteriorly. Antenna 1 peduncle with 4, 6 and 4 long marginal setae on articles 1, 2 and 3 respectively and with marginal brush-setae on articles 1 and 2. Mandibular palp articles with 1, 3 and 3 setae respectively. Maxilliped article 4 with 3 mesial setae, 1 laterally and 2 distally; article 5 with 5 setae, exceeding distal margin of article 4; surface of articles 4 and 5 with fine hairs.

Pereopod 1 article 4 with 11 mesial setae along anterior margin; article 5 with 6 mesial setae, its distal tooth blunt; article 6 palm with tooth more or less developed at midpoint, 10 marginal setae and numerous setae on mesial face. Pereopod 2 article 4 with 6 anterior setae, with a setose posterior lobe produced distally to shield article 5; article 5 well produced distally into a rounded setose lobe; article 6 ovoid, mesially setose and with long setae only along posterior margin. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with articles 4 and 5 having lobed posterior margins bearing numerous long setae.

Uropodal endopod with a discontinuous row of long setae along lateral and terminal margin; 3 brush-setae in hiatus of setal row and 2 others dorsally. Exopod $1.8\times$ as long as greatest width, distal lobes rounded and separated by an obtuse angular notch; dorsal margin gently convex.

Telson $1.3\times$ as long as pleon, $2.2\times$ as long as greatest width, lateral margins sharply angled two-thirds way along, distally almost concave and tapering to sharply rounded apex; not

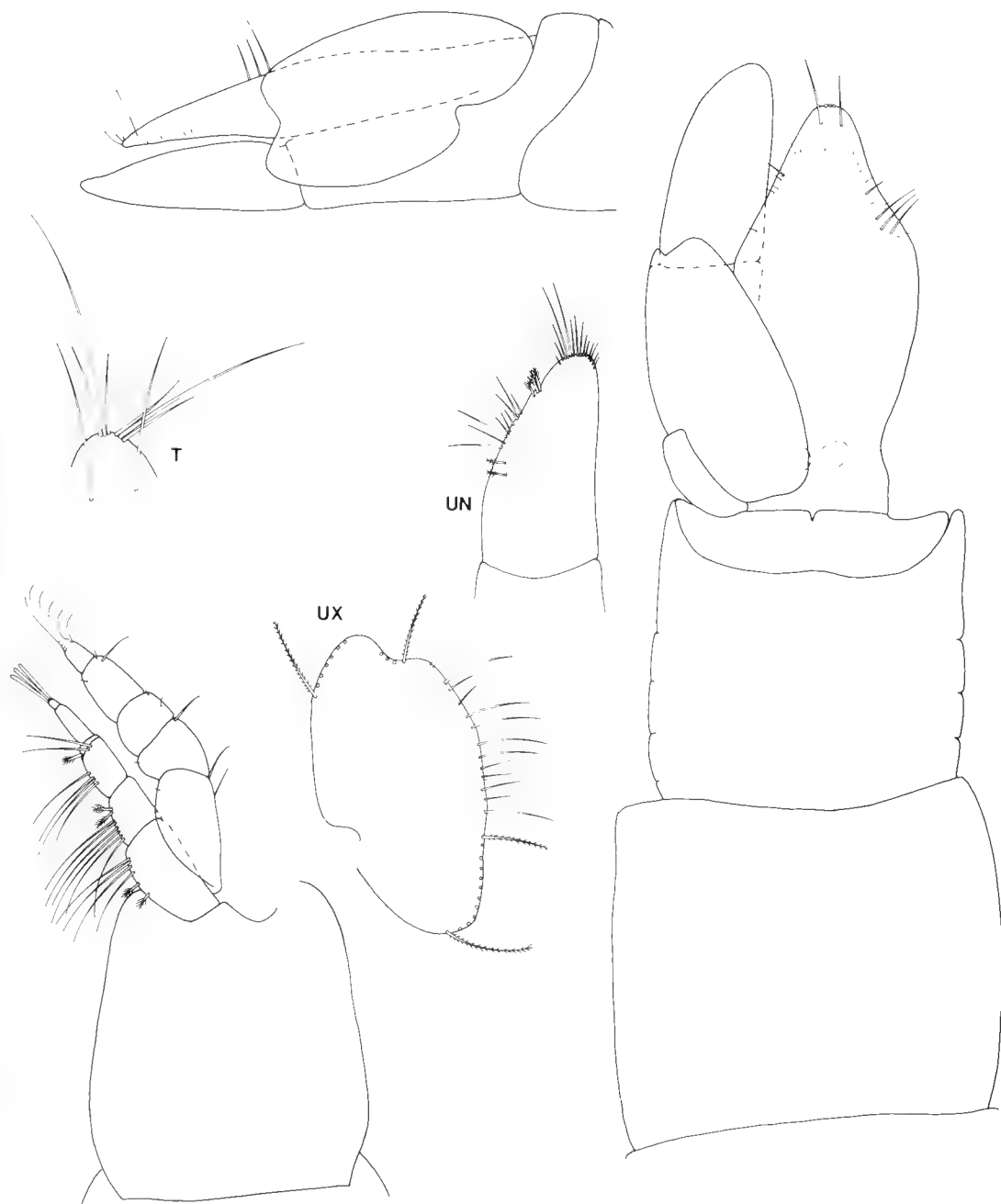


Figure 9. *Apanthura isotoma*. Holotype juvenile, 10.5 mm.

strongly convex in longitudinal section; a pair of dorsal setae near apex, others near margin in distal third.

Male: Antenna 1 with flagellum of 12 articles

reaching back to posterior margin of head. Eyes enlarged. Pereopod 1 with article 5 more elongate and tooth more projecting than in juvenile; article 6 lacking palmar tooth, mesial

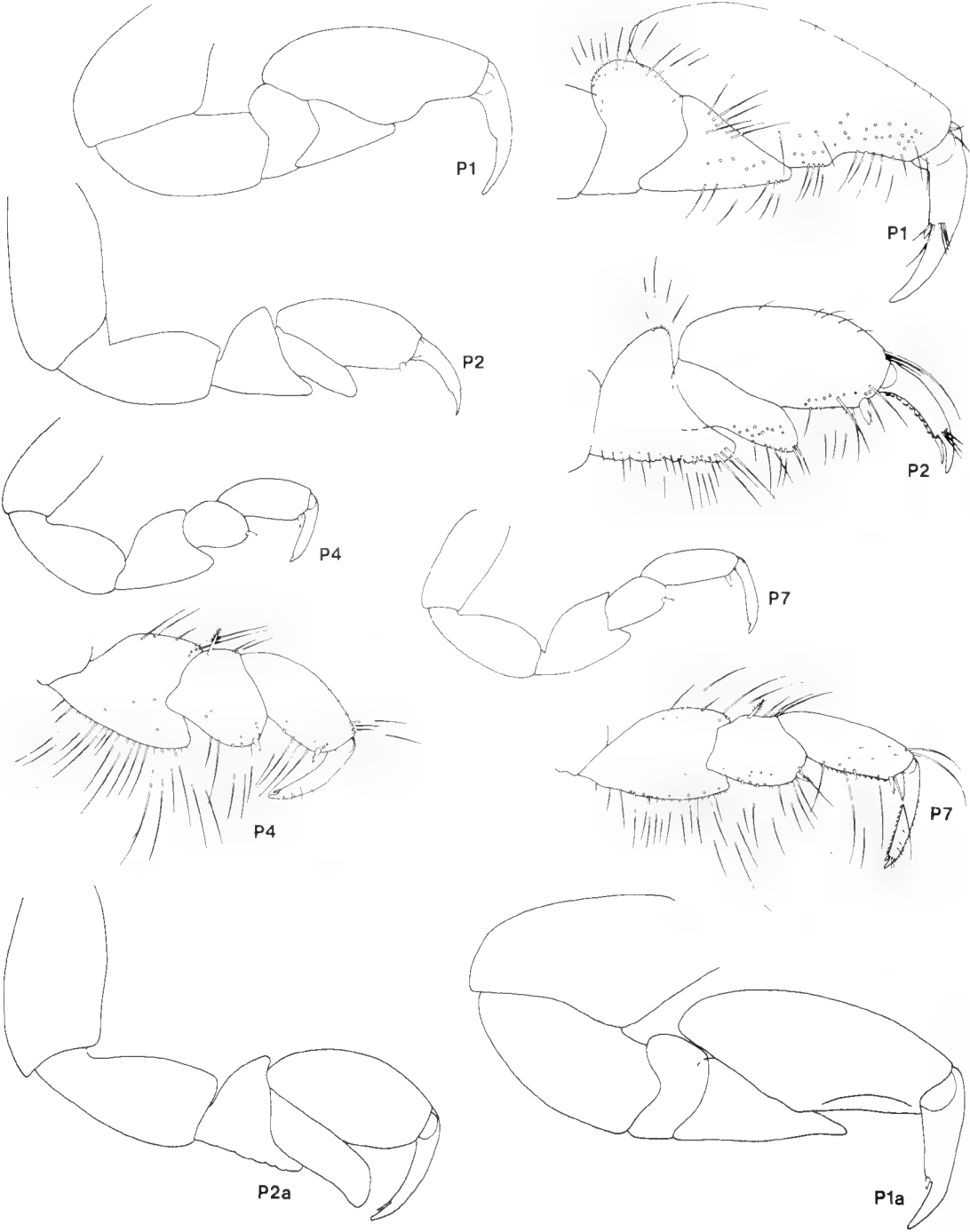


Figure 10. *Apanthura isotoma*. Holotype juvenile, 10.5 mm; a, paratype male, 12.0 mm, NMVJ1489.

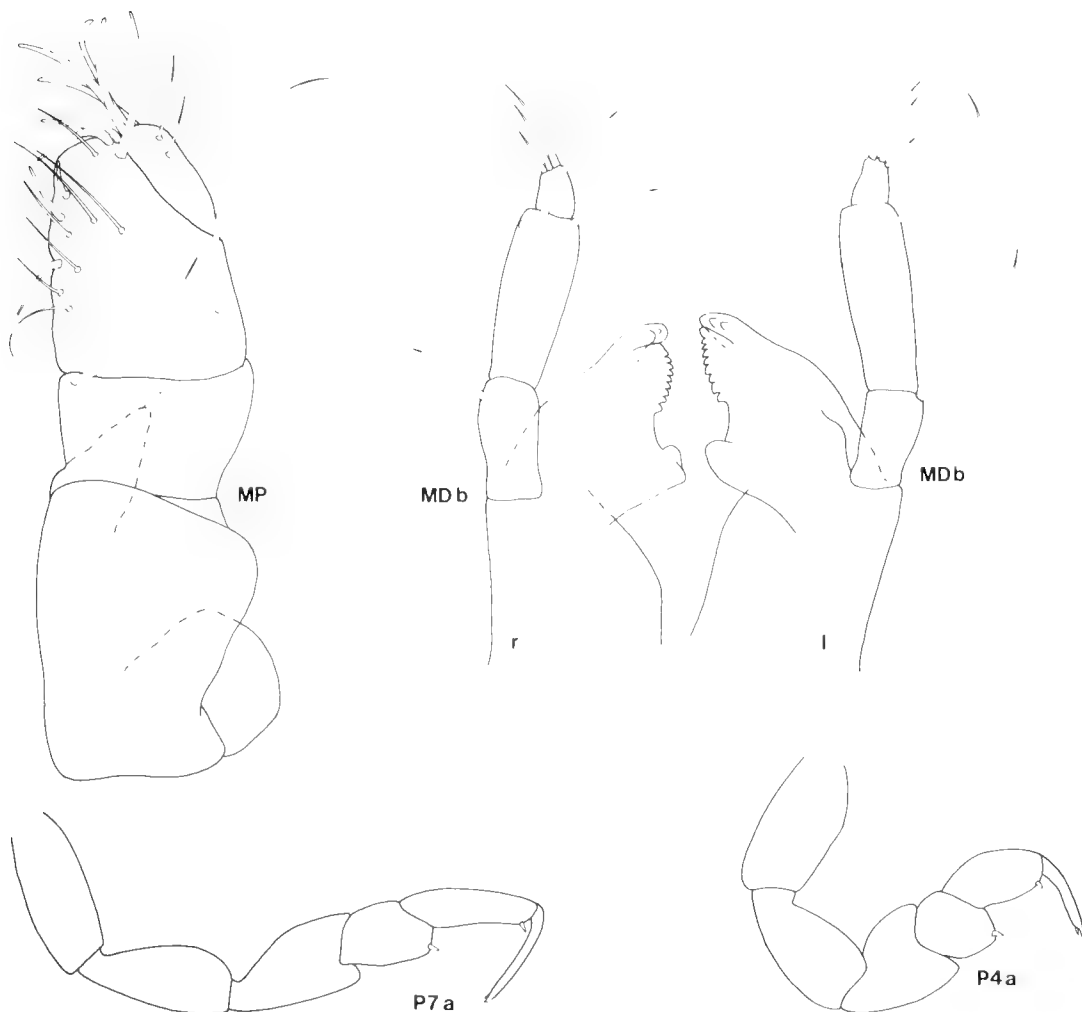


Figure 11. *Apanthura isotoma*. Paratype male, 12.0 mm, NMVJ1489; a, paratype juvenile, 11.9 mm, NMVJ1487; b, paratype juvenile, 7.6 mm, NMVJ1490; l, left; r, right.

setae more numerous. Pereopods 2 and 3 article 5 with a strongly produced broad posterior lobe. Most posterior pereopods slightly more elongate than in juvenile. Appendix masculina on pleopod 2 a simple rod not reaching to end of endopod. Pereonite 1 with a ventral keel anteriorly between pereopods. Uropodal rami slightly more elongate.

Distribution: Tasmania, Victoria and New South Wales, sandy sediment, shelf and oceanic parts of bays.

Remarks: *Apanthura isotoma* is a typical species of *Apanthura* species-group 2 with well-

developed lobes on the posterior pereopods and particularly setose antenna 1. It is the most widespread species of *Apanthura*, distinguished from others by the tapered apex of the telson.

***Apanthura lambertia* sp. nov.**

Figures 12-14

Material examined: 23 males, 189 juveniles; 5.3-14.7 mm:

Holotype: juvenile, 13.5 mm, QMW10021 (with one slide). Qld, Moreton Bay, Middle Banks, W. of Tangalooma, S. Cook and S. Newlands (QUBS station), Sept 1973.

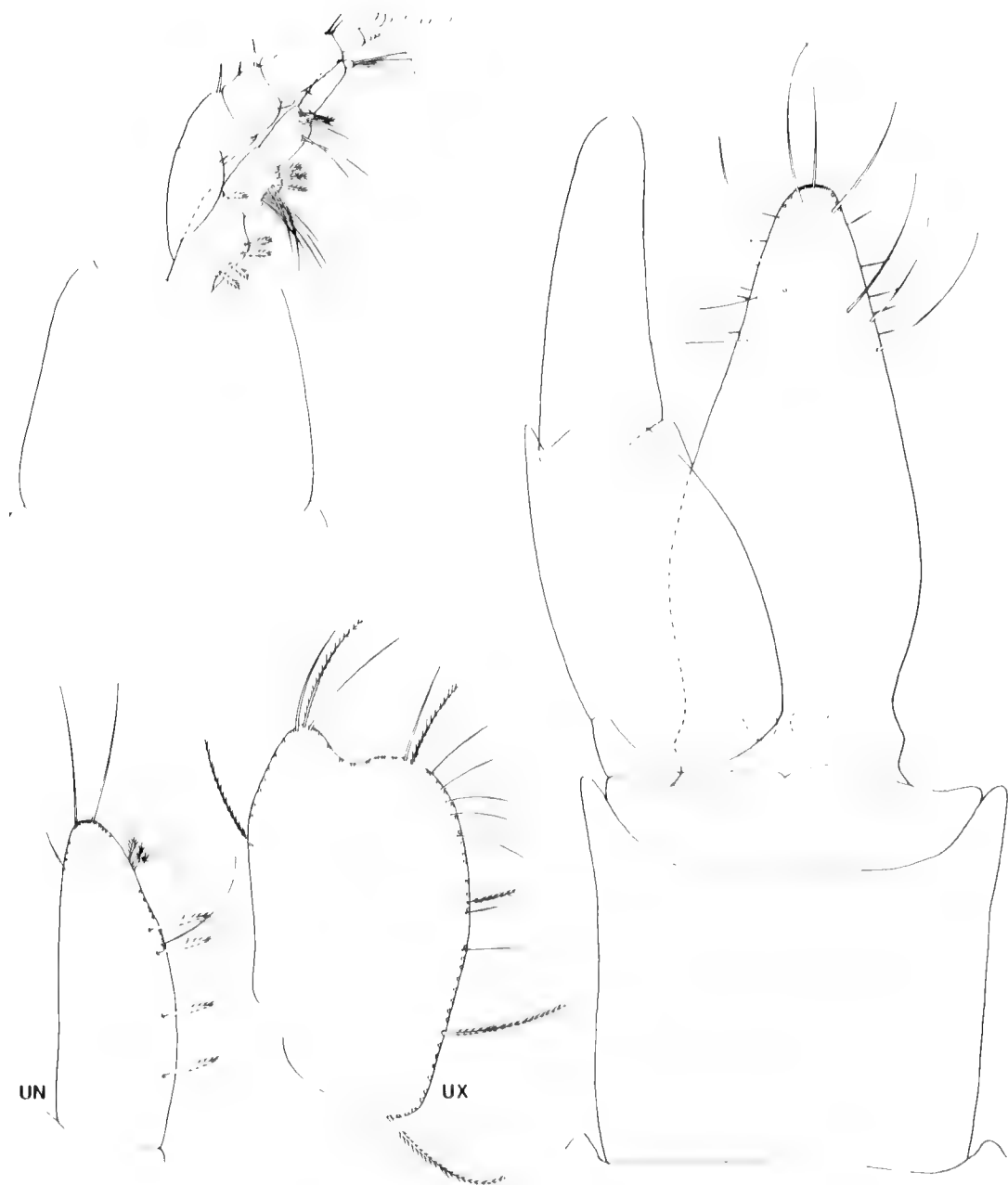


Figure 12. *Aphantura lambertia*, Holotype juvenile, 13.5 mm.

Paratypes: Qld, type locality, QMW10023 (1 male, QMW10022(1), QMW4733(16), NMVJ 2912 (1 male, 3 juveniles), AMP33583 (1 male, 2 juveniles).

Other material: Qld, Moreton Bay, QUBS

stations, QMW4726(40), QMW4729-32(79), QMW4735-6(29), QMW8386(9), QMW8457 (6), QMW10024-8(22).

Description: Integument not pigmented. Eyes present. Head as long as wide, tapering

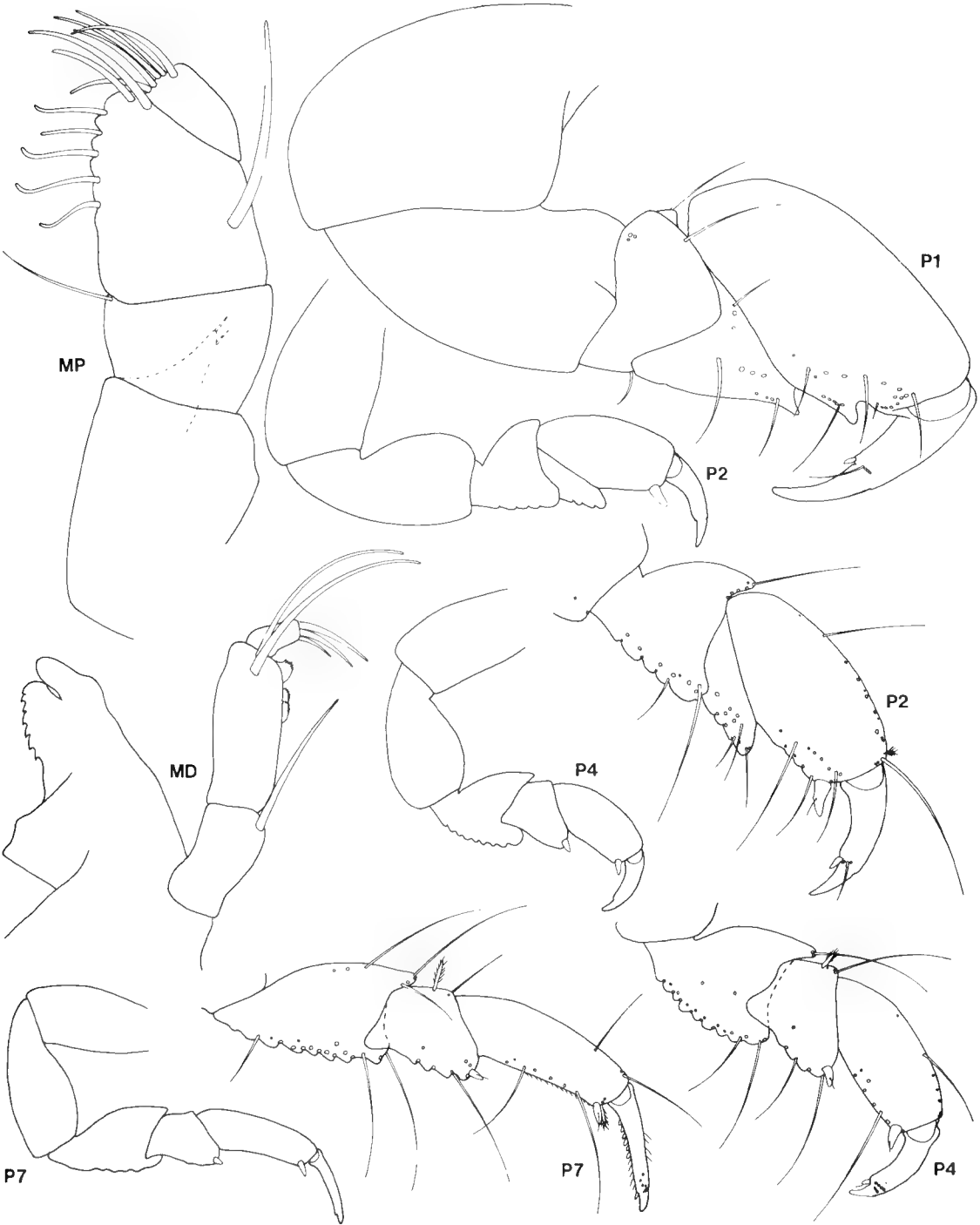


Figure 13. *Apanthura lambertia*. Holotype juvenile, 13.5 mm.

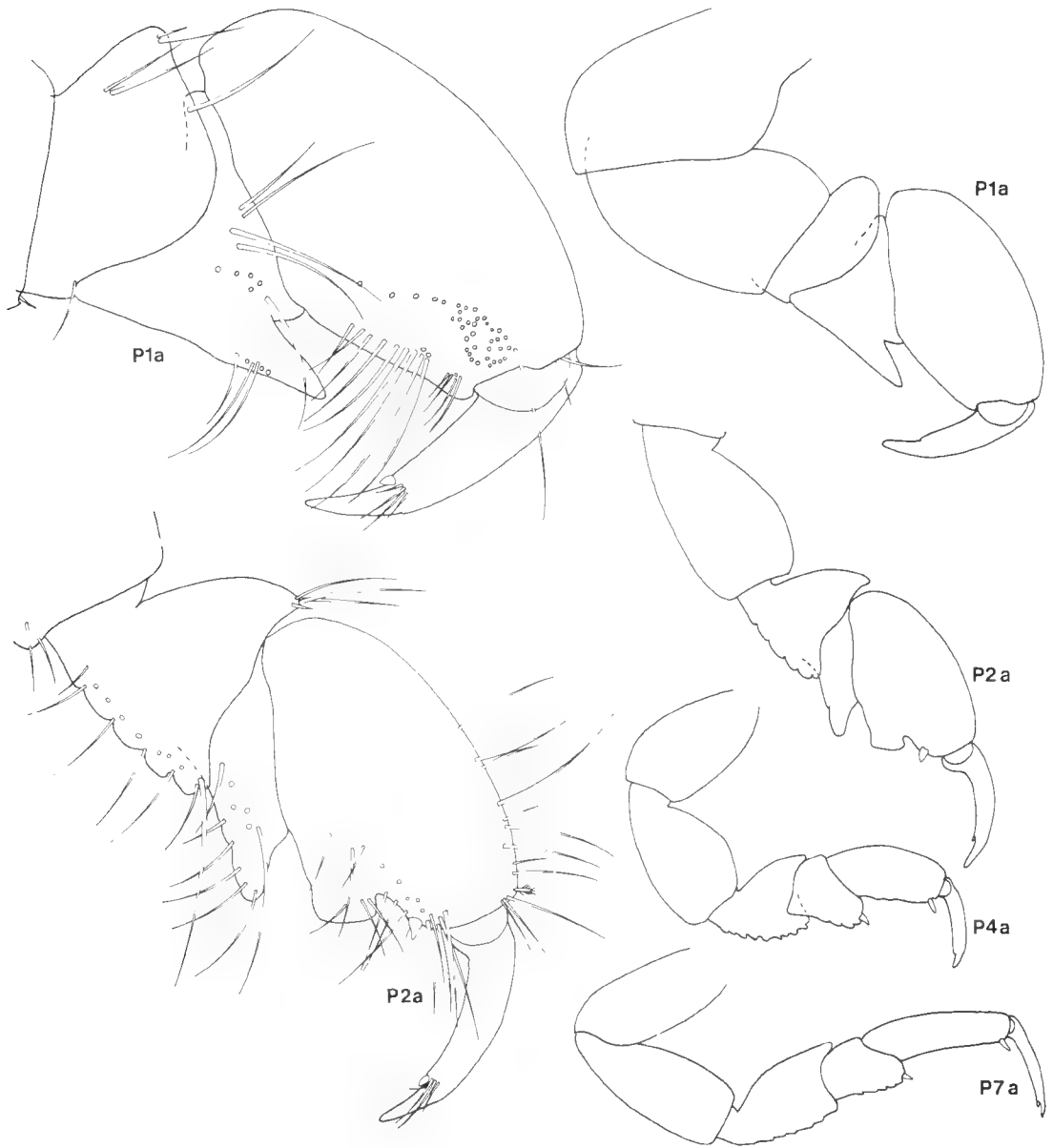


Figure 14. *Apanthura lambertia*. Paratype male, 13.9 mm, QMW10023.

anteriorly. Antenna 1 peduncle with 6 and 2-4 marginal setae on articles 2 and 3 respectively and with marginal brush-setae on articles 1 and 2. Mandibular palp barely reaching tip of incisor, articles with 1, 2 and 3 setae respectively. Maxilliped article 4 with 5 mesial setae, 1

laterally and 2 distally; article 5 with 5 setae, clearly exceeding distal margin of article 4; surface of article 4 sometimes with fine hairs.

Pereopod 1 articles 4 and 5 each with 3-4 mesial setae along anterior margin; article 5 with a pronounced distal tooth; article 6 palm

with a pronounced tooth at midpoint, a proximal marginal row of 6 setae and about 17 setae on mesial face. Pereopod 2 article 4 with 7 anterior setae, with a setose posterior lobe produced distally to shield article 5 only slightly; article 5 well produced distally into a blunt setose lobe; article 6 linear-ovoid, mesially setose, and with setae along length of anterior and posterior margins. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with articles 4-5 having lobed posterior margins bearing numerous long setae.

Uropodal endopod with a discontinuous row of long setae along lateral and terminal margin; 3 brush-setae in hiatus of setal row and 4 others dorsally. Exopod $1.8\times$ as long as greatest width, ventral distal lobe acute and separated from a very broadly rounded dorsal lobe by a curved notch; dorsal margin gently convex. Telson $1.5\times$ as long as pleon, $2.4\times$ as long as greatest width, widest at proximal third and tapering evenly to a sharply rounded apex; not strongly convex in longitudinal section, about 8 dorsal setae near margin on distal quarter.

Male: Antenna 1 with flagellum of 10 articles reaching back to posterior margin of head. Eyes enlarged. Pereopod 1 with article 5 having a more pronounced tooth, article 6 lacking a palmar tooth, mesial setae more numerous. Pereopod 2 palm produced proximally as a broad truncate blade; pereopod 3 similar but less well developed. Most posterior pereopods slightly more elongate than in juvenile. Pleon and telson more elongate than in juvenile. Appendix masculina on pleopod 2 a simple rod, not reaching to end of endopod.

Distribution: Queensland, Moreton Bay, sandy sediments.

Remarks: *Apanthura lambertia*, a member of species-group 2, is immediately differentiated from other species by its elongate tapering telson and the extreme modification of the male pereopods.

The species is confined to Moreton Bay where it is common. A single male from Port Phillip Bay, Vic. (*Apanthura* sp. herein) is similar to *A. lambertia* but juveniles able to be associated with it could not be found.

Apanthura mirbelia sp. nov.

Figures 15-17

Material examined: 1 male, 5 juveniles; 5.2-14.8 mm:

Holotype: juvenile, 11.2 mm, NMVJ2917 (with one slide), Bass Strait ($40^{\circ}40'S.$, $145^{\circ}15'E.$), 33 m, medium shell-sand, 4 Nov 1980 (BSS stn 115).

Paratypes: Bass Strait, type locality, NMVJ2918 (1 specimen), NMVJ2919 (1 male). Bass Strait: $40^{\circ}24'S.$, $145^{\circ}32'E.$ (BSS stn 113), NMVJ2920(3); $39^{\circ}02.4'S.$, $148^{\circ}30.6'E.$ (BSS stn 169), NMVJ2921(1), J3034(1).

Description: Integument not pigmented. Eyes present. Head $1.2\times$ as long as wide, tapering anteriorly. Antenna 1 peduncle with 1 long marginal seta on article 3, 1 very short seta and marginal brush-seta on both articles 1 and 2. Mandibular palp articles with 1, 2 and 4 setae respectively, molar with a small distal accessory tooth. Maxilliped article 4 with 2 mesial setae, 1 laterally and 2 distally; article 5 with 5 setae, reaching level with end of article 4; surface of articles 4 and 5 with few fine hairs.

Pereopod 1 articles 4 and 5 each with 1-2 mesial setae along anterior margin; article 5 with a pronounced distal tooth; article 6 palm with a pronounced tooth at midpoint, 9 marginal setae and numerous setae on mesial face. Pereopod 2 article 4 with 2 anterior setae, its posterior margin scarcely produced distally; article 5 only slightly produced distally into a blunt setose lobe; article 6 linear-ovoid, not mesially setose, and without long setae on anterior margin. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with only articles 5 distally lobed.

Pleonal sutures visible dorsolaterally.

Uropodal endopod with a continuous row of long setae along lateral and terminal margin; 3 brush-setae on distolateral margin and 4 others dorsally. Exopod $1.7\times$ as long as greatest width, ventral distal lobe acutely rounded and separated from the bigger rounded dorsal lobe by an obtuse angular notch; dorsal margin gently convex. Telson $1.4\times$ as long as pleon, $2.2\times$ as long as greatest width, lateral margins smoothly convex and tapering to a broadly

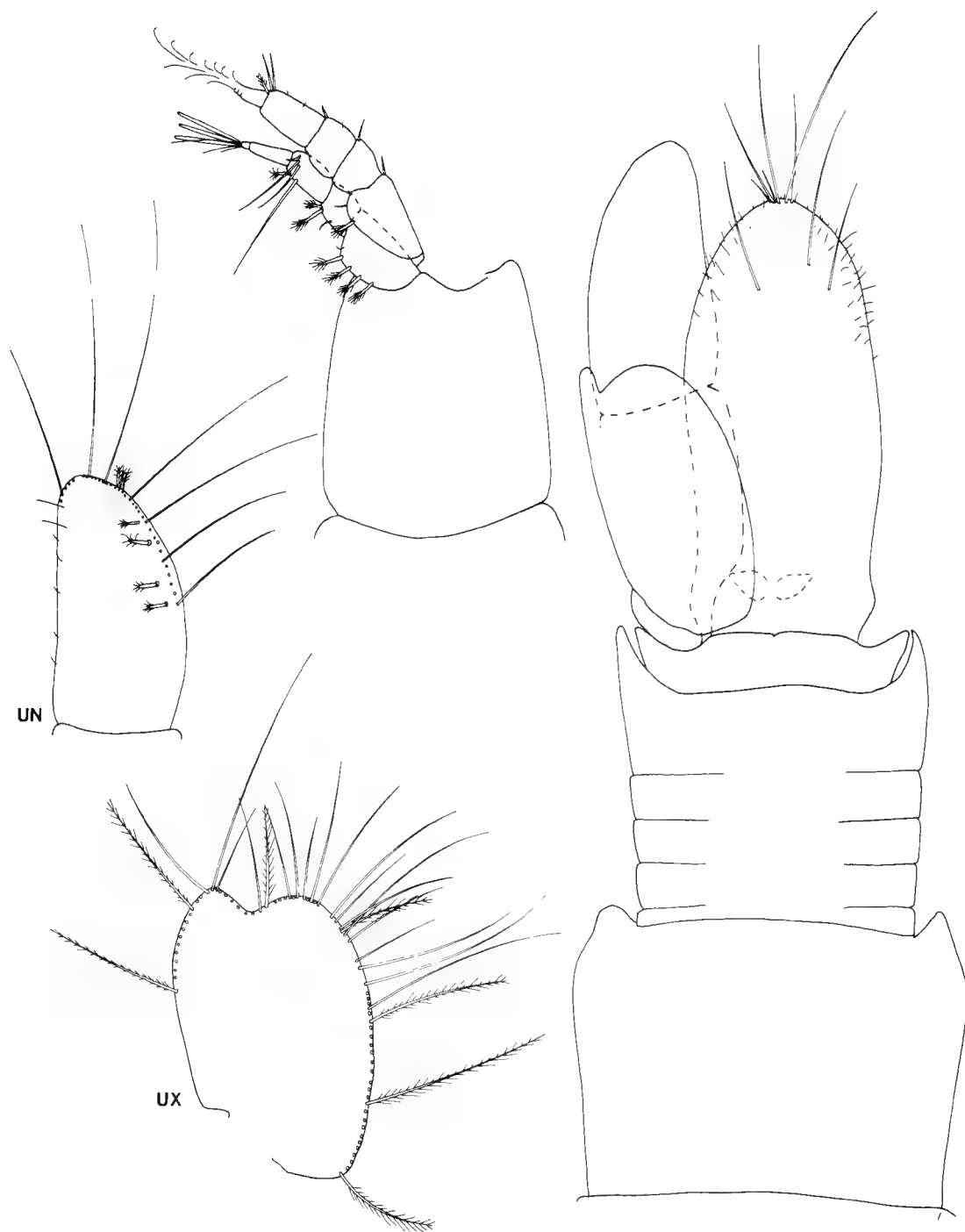


Figure 15. *Apanthura mirbelia*. Holotype juvenile, 11.2 mm.

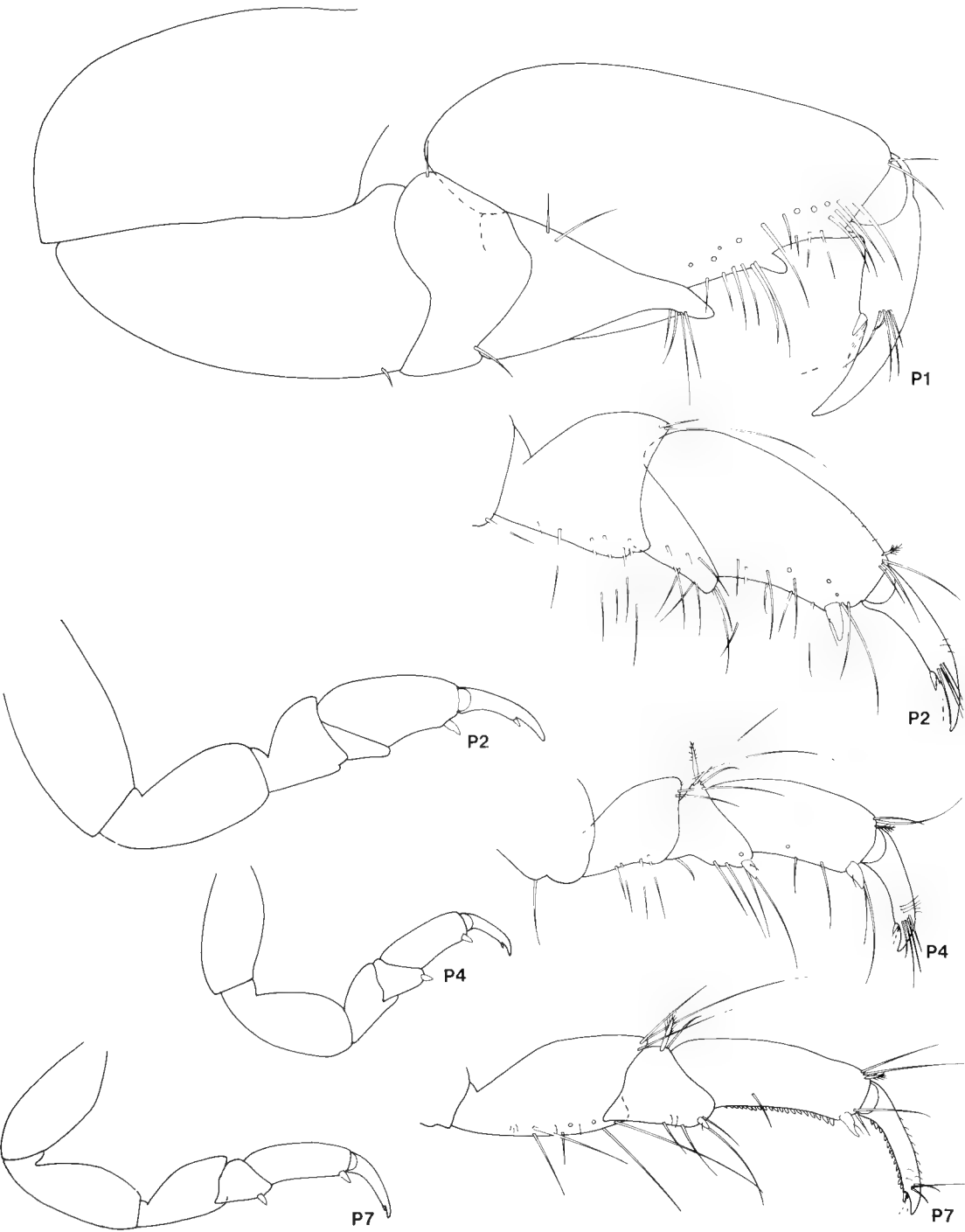


Figure 16. *Apanthura mirbelia*. Holotype juvenile, 11.2 mm.

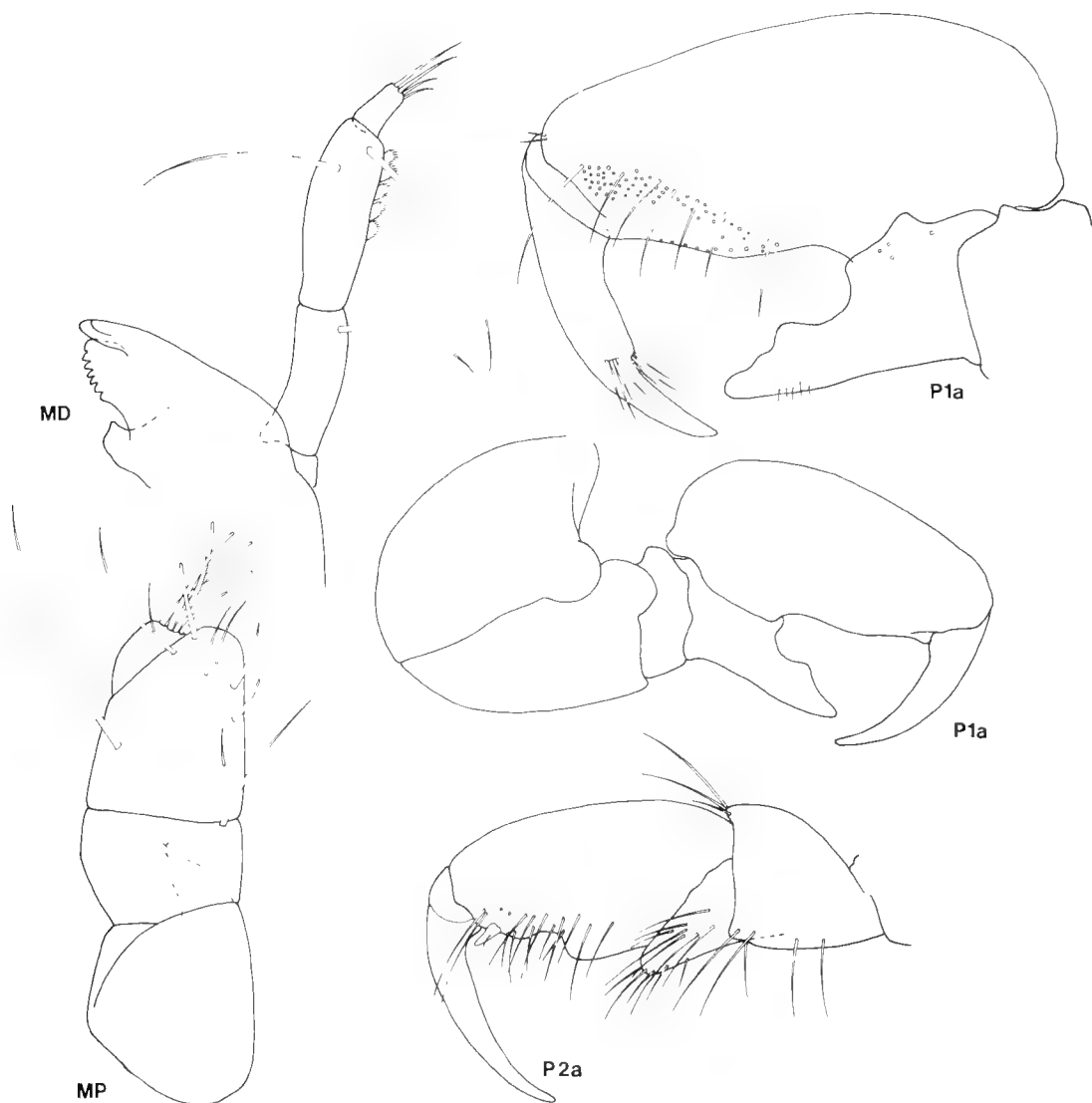


Figure 17. *Apanthura mirbelia*. Holotype juvenile, 11.2 mm; a, paratype male, 12.1 mm, NMVJ2919.

rounded apex, a few long dorsal setae near apex, finer hairs near margin.

Male: Antenna 1 with flagellum of 10 articles reaching back to posterior margin of head. Eyes enlarged. Pereopod 1 with article 5 grossly expanded distoposteriorly, its tooth with a complex inside edge; article 6 lacking a palmar tooth, with numerous mesial setae. Pereopod 2 article 6 with a proximal posterior lobe. Pereopod 3 similar but less modified. Most posterior pereopods slightly more elongate than in juvenile. Appendix masculina on pleopod 2 a

simple rod not reaching to end of endopod. Uropodal rami slightly more elongate.

Distribution: Bass Strait, 37-120 m, muddy sand.

Remarks: *Apanthura mirbelia* is a typical member of species-group 1. It is the only Australian species in which some trace of the pleonal sutures remains. The most remarkable feature of this species is the male pereopod 1 in which the palmar tooth is absent and the tooth on article 5 is grossly expanded. Pereopods 2 and 3 of the male are also modified, having the palm lobed, especially proximally.

***Apanthura styphelia* sp. nov.**

Figures 18, 19

Material examined: 3 males, 40 juveniles; 3.3–11.6 mm:

Holotype: juvenile, 7.2 mm, NMVJ3012 (with one slide). NSW, Port Hacking, Gunnamatta Bay (34°06'S, 151°10'E.), sand, 3 m, 18 Jan 1975 (CSIRO stn G2).

Paratypes: NSW, type locality, NMVJ3013 (1 specimen); 18 Feb 1975, NMVJ3014(5). Port Jackson, Bottle and Glass Rocks, 5 m, AMP33586(1). Off Sydney, AMSBS stn C7S5, 24 m, AMP24353(1).

Vic., Port Phillip Bay, PPBES stations: stn 907, NMVJ3015(2); stn 908, NMVJ3016(1); stn 918, AMP33587(4); stn 922, NMVJ3017(1); stn 928, NMVJ3018(1), J3055(1); stn 944, NMVJ3019(12); stn 980, NMVJ3020(1); stn 985, NMVJ3021(6), NMVJ3022 (1 male). Hobsons Bay, NMVJ3023(5). Western Port, WBES stn 1704, NMVJ3054(1); stn 1735, NMVJ3033(1).

Description: Integument not pigmented. Eyes present. Head $1.2\times$ as long as wide, lateral margins convex. Antenna 1 peduncle with 1 long marginal seta on article 3, 1 short seta on article 2, and with marginal brush-setae on articles 1 and 2. Mandibular palp articles with 1, 2 and 3 setae respectively. Maxilliped article 4 without mesial setae, 1 seta laterally and 2 distally; article 5 with 5 setae, exceeding distal margin of article 4.

Pereopod 1 article 4 with 2 mesial setae on anterior margin; article 5 with a pronounced distal tooth; article 6 palm with a pronounced tooth at midpoint, 6 marginal setae and 8 stout setae on mesial face. Pereopod 2 article 4 with 2 anterior setae, its posterior margin not produced distally; article 5 barely produced distally into a blunt lobe; article 6 linear-ovoid, with 3 mesial setae and without setae on anterior margin. Pereopod 3 similar to 2, but smaller. Pereopods 4–7 with only article 5 distally lobed.

Uropodal endopod with a continuous row of long setae along lateral and terminal margin; 3 brush-setae on distolateral margin and 4 others dorsally. Exopod $1.7\times$ as long as greatest width, ventral distal lobe acute and separated

from the rounded dorsal lobe by an acute angular notch; dorsal margin gently convex. Telson $1.4\times$ as long as pleon, $1.8\times$ as long as greatest width, lateral margins with greatest curvature at midpoint and tapering to broadly rounded apex; 2 pairs of dorsal setae at three-quarter mark, few marginal setae; telson flat in profile, lateral flanges quite thin.

Male: Antenna 1 flagellum with 5 articles reaching back to posterior margin of head. Eyes enlarged. Pereopod 1 with article 5 having a prominent tooth; article 6 elongated, with a substantial palmer tooth distad to midpoint; with numerous mesial setae. Other pereopods more elongate. Appendix masculina on pleopod 2 a simple rod not reaching to end of endopod. Uropodal rami more elongate than in juvenile.

Distribution: New South Wales and Victoria, 2–31 m, sandy substrates.

Remarks: *Apanthura styphelia* has all the attributes of *Apanthura* species-group 1. The species is noted for the very flat nature of the telson, especially laterally, and is separated from *A. thryptomene* by the paucity of dorsal setae on the telson. The male is distinguished by the distal position of the palmer tooth on pereopod 1, a feature not seen elsewhere in the genus.

***Apanthura thryptomene* sp. nov.**

Figures 20–22

Material examined: 7 juveniles; 10.0–10.7 mm:

Holotype: juvenile, 10.7 mm, NMVJ2970 (with one slide). Vic., Western Port (38°27.53'S., 145°08.59'E.), 18 m, sand, 25 Nov 1974 (WBES stn 1747).

Paratypes: Vic., type locality: NMVJ2971 (1 specimen), NMVJ2972(1). Western Port, WBES stations: stn 1704, NMVJ2973(1); stn 1730, NMVJ2974(1); stn 1736, NMVJ3010(1). Western Port, Crib Point, CPBS stn 40E, Dec 1972, NMVJ3011(1).

Description: Integument not pigmented. Eyes present. Head $1.3\times$ as long as wide, tapering anteriorly; with a prominent ventral lobe at base of maxillipeds. Antenna 1 peduncle with 1 long marginal seta on article 3, 1 short seta and



Figure 18. *Apanthura styphelia*. Holotype juvenile, 7.1 mm.

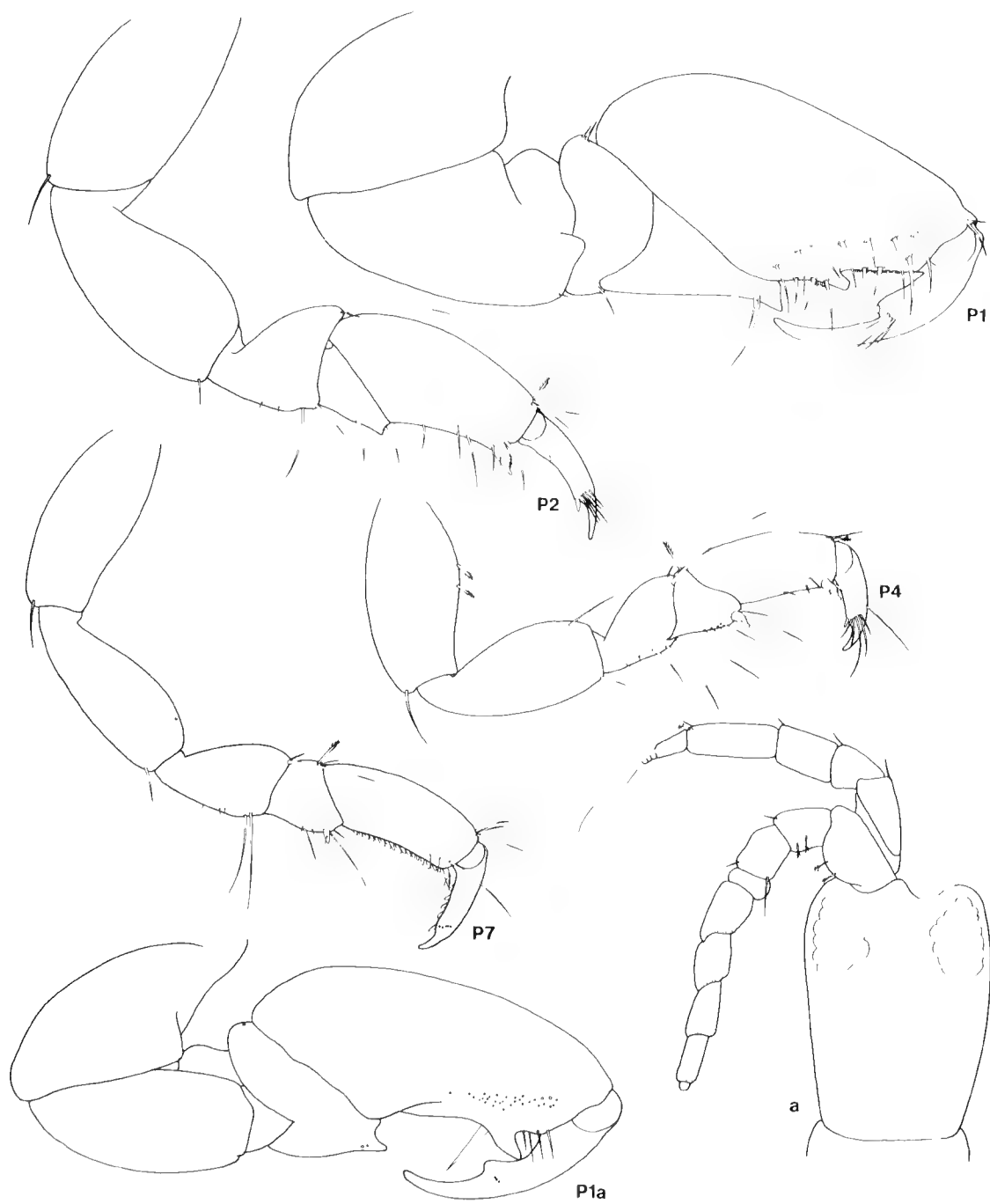


Figure 19. *Apanthura styphelia*. Holotype juvenile, 7.1 mm; a, paratype male, 5.9 mm, NMVJ3022.

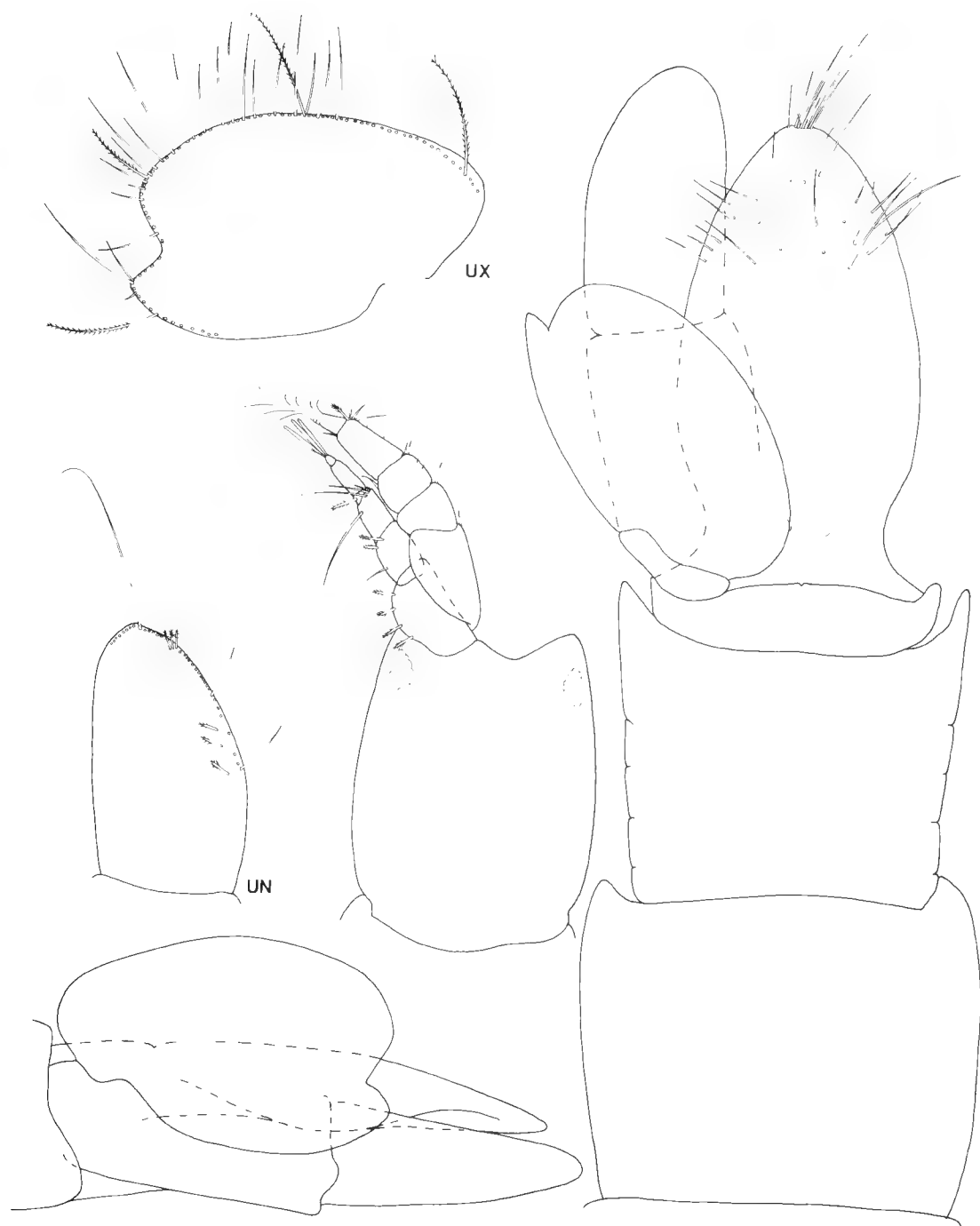


Figure 20. *Apanthura thryptomene*. Holotype juvenile, 10.7 mm.



Figure 21. *Apanthura thryptomene*. Holotype juvenile, 10.7 mm.



Figure 22. *Apanthura thryptomene*. Holotype juvenile, 10.7 mm.

marginal brush-seta on both articles 1 and 2. Mandibular palp articles with 1, 3 and 3 setae respectively. Maxilliped article 4 with 3 mesial setae, 1 laterally and 2 distally; article 5 with 5 setae, exceeding end of article 4.

Pereopod 1 article 5 with 8 mesial setae along anterior margin and with a pronounced distal tooth; article 6 palm with a pronounced tooth at midpoint, 11 marginal setae and about 20 setae on mesial face. Pereopod 2 article 4 with 4 anterior setae, with a sparsely setose posterior margin barely produced distally; article 5 produced distally into an acute lobe; article 6 linear-ovoid, with few mesial setae and no long setae on anterior margin. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with article 4 having a convex posterior margin bearing few long setae, article 5 with a short truncate distal lobe.

Uropodal endopod with a continuous row of long setae along lateral and terminal margin; 3 brush-setae on distolateral margin and 3 others dorsally. Exopod $1.6\times$ as long as greatest width, ventral distal lobe acute and separated from broader dorsal lobe and convex dorsal margin by an obtuse notch.

Telson $1.4\times$ as long as pleon, $1.9\times$ as long as greatest width, lateral margins strongly convex and tapering from proximal third to a narrowly rounded apex; about 6 pairs of long dorsal setae on distal third.

Male: Unknown.

Distribution: Victoria, Western Port, 8-18 m; sandy substrates.

Remarks: *Apanthura thryptomene*, a typical member of *Apanthura* species-group 1, is separated from all others by the prominent ventral lobe at the base of the maxillipeds. A similar lobe is found in males of *A. xanthorrhoea*, for example, but is not well-developed in juveniles of any other species. The male of *A. thryptomene* is not known. The telson of this species is especially setose distally.

***Apanthura xanthorrhoea* sp. nov.**

Figures 23, 24

Mesanthura maculata.—Tubb, 1937: 409 (not Haswell, 1881).

Material examined: 2 males, 19 juveniles, 10.3-16.4 mm:

Holotype: juvenile, 12.7 mm, NMVJ2992 (with one slide), Western Port, Corinella (38°25'S., 145°26'E.), Marine Study Group, 9 Dec 1969.

Paratypes: Vic., type locality, NMVJ2993 (1 specimen). Point Lonsdale, Marine Study Group, 12 Mar 1972, NMVJ2995(10). Western Port, Honeysuckle Point, T. Crawford, 29 Dec 1962, NMVJ2996(2). Phillip Island, Red Rock, sublittoral, W. F. Seed *et al.*, 29 Sept 1974, NMVJ2997(1). Western Port, Crib Point, CPBS stn 34N, NMVJ3035(1). Harmers Haven, intertidal, G. Poore, 6 Mar 1982 (CPA stn 23), NMVJ2998(1). Lady Julia Percy Island, Dinghy Bay, 6 m, McCoy Society, summer 1935-6, NMVJ2994(1).

Tas., Greens Beach, QVM 1982/10/1 (1 male, 2 juveniles). Cape Portland, 3 m, G. Edgar, 11 Jan 1981, NMVJ2999 (1 male). Schouten Passage, N. of Schouten Is., 12 m, A. J. Dartnall, 8 Jun 1977, NMVJ4444(6).

NSW, Jervis Bay, off Moona Moona Creek, 3 m, algae and sediment, J. K. Lowry (stn NSW-115), AMP33585(1). Port Hacking, Gunnamatta Bay, NMVJ3057(1). North Head, 29 m, 26 May 1972, AMP22810(1); 33 m, 23 May 1972, AMP24352(1). Lord Howe Island, reef front S. of North Passage, eelgrass, 3m, J. K. Lowry, 11 May 1977, AMP29808(2).

SA, Sellicks Beach, underside of boulders on reef, H. M. Hale, 27 Jan 1937. SAM(4).

Description: Integument pigmented; head, pereonites, pleon and telson with dendritic dorsal pigment patches. Eyes present. Head 1.3 × as long as wide, not tapering anteriorly; with a prominent ventral lobe at the base of the maxillipeds. Antenna 1 peduncle with 1 long marginal seta on article 3, 1 short seta and marginal brush-setae on both articles 1 and 2. Mandibular palp articles with 1, 2 and 4 setae respectively. Maxilliped article 4 with 3 mesial setae, 1 laterally and 2 distally; article 5 with 5 setae, exceeding end of article 4.

Pereopod 1 article 5 with only 2 mesial setae near anterior margin and with pronounced distal tooth; article 6 palm with pronounced tooth at midpoint, 8 marginal setae and about 11 setae on mesial face. Pereopod 2 article 4 with 4 anterior setae, with a sparsely setose posterior margin, not produced distally; article

5 produced distally into a truncate lobe; article 6 linear-ovoid, with few mesial setae, and no long setae on anterior margin. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with article 4 having convex posterior margin bearing few long setae, article 5 with a short truncate distal lobe.

Uropodal endopod with a continuous row of long setae along lateral and terminal margin; 3 brush-setae on distolateral margin and 4 others dorsally. Exopod 1.7 × as long as greatest width, ventral distal lobe small and acute, separated from rounded dorsal lobe by a deep notch; dorsal margin convex. Telson 1.4 × as long as pleon, 2.2 × as long as greatest width, lateral margins evenly convex and tapering from midpoint to a rounded apex; 6 pairs of dorsal setae on distal third.

Male: Antenna 1 with flagellum of 8 articles reaching back to pereonite 1. Eyes enlarged. Ventral lobe on head grossly expanded. Pereopod 1 with article 5 having a prominently projecting tooth; article 6 swollen, possessing a palmar tooth; mesial setae more numerous. Other pereopods with distal articles more elongate than in juvenile. Appendix masculina on pleopod 2 a simple rod not reaching to the end of the endopod. Uropodal rami not more elongate than in juvenile.

Distribution: South Australia, Victoria, Tasmania and New South Wales; intertidal-33 m.

Remarks: *Apanthura xanthorrhoea* has a more elongate telson than the other species of *Apanthura* species-group 1 to which it belongs. There is a slight ventral lobe at the base of the maxillipeds of juveniles but this is extraordinarily well developed in males. The palm of pereopod 1 is more oblique and shorter than in other species and in males is complemented by a tooth on article 5.

The species is notable for the possession of persistent dorsal pigmentation which probably induced Tubb (1937) to place his specimen from Lady Julia Percy Island in *Mesanthura*. *Apanthura xanthorrhoea* is similar to *A. dimorpha* (Kensley) from South Africa particularly in the male pereopod 1 and head.

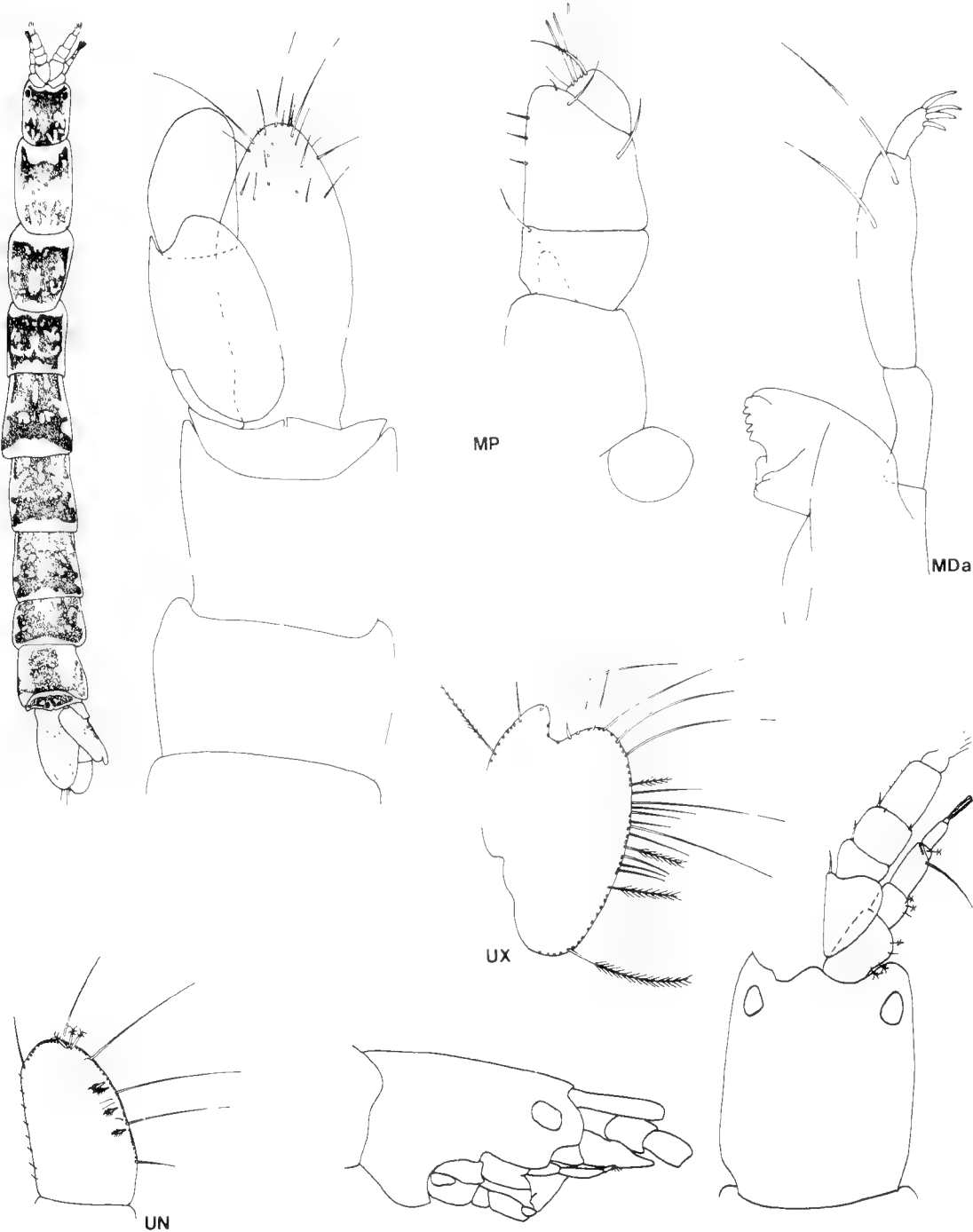


Figure 23. *Apanthura xanthorrhoea*. Holotype juvenile, 12.7 mm; a, paratype male, 14.0 mm, NMVJ2999.

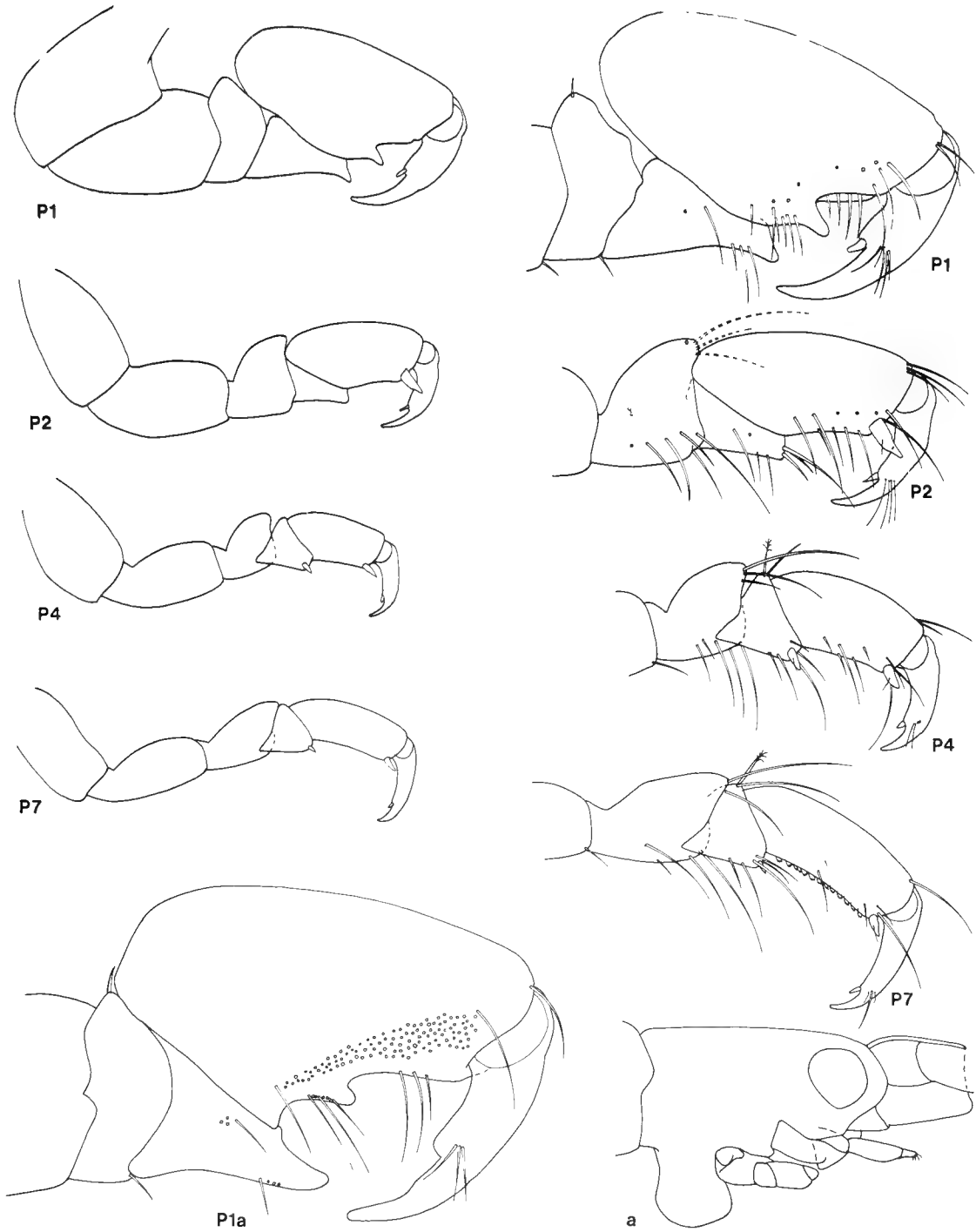


Figure 24. *Apanthura xanthorrhoea*. Holotype juvenile, 12.7 mm; a, paratype male, 14.0 mm, NMVJ2999.

Apanthura sp.

Figure 25

Material examined: Vic., Port Phillip Bay (38°14.0'S., 144°46.3'E.), sand, 8 m (PPBES stn 968), NMVJ3056 (1 male, 12.1 mm).

Remarks: A single male specimen from Port Phillip Bay could not be assigned to any of the species described here. The pereopods are similar to males of *A. lambertia* from Moreton Bay, Qld, but sufficient differences could be found in this character and between the telsons of the two species to distinguish them. Being male, the species does not appear in the key.

Apanthuretta Wägele

Apanthuretta (nomen nudum) Wägele, 1981a: 85, 112, fig. 37.

Apanthuretta Wägele, 1981b: 134-5.

Diagnosis: Integument smooth, sometimes pigmented. Eyes present. Antenna 1 flagellum short, of 3 articles, the last minute and bearing 3 aesthetascs. Antenna 2 flagellum short, of 2-4 articles. Mandibles symmetrical, not sexually dimorphic; incisor, lamina dentata and blunt molar present; palp 3-articled, article 3 one-third length of article 2, with 3-4 terminal setae. Maxilliped of five articles and bearing an acute endite with terminal seta; article 3 wider than long; article 4 usually with row of mesial setae; article 5 oblique, subterminal, much smaller than 4, with 4-5 apical setae.

Pereopod 1 subchelate, article 6 swollen, palm stepped (sometimes toothed), with stout mesial setae. Pereopods 2 and 3 with article 6 only little more robust than on posterior pereopods. Pereopods 4-7 with triangular-trapeziform article 5, with free anterior margin.

Pleon as long as pereonite 7, longer than wide; pleonites 1-4 separated dorsally by an integumental fold, 4-5 fused mid-dorsally, pleonite 6 free from others and from telson. Pleopod 1 exopod operculiform, endopod setose; pleopods 2-5 setose. Uropodal endopod as long as peduncle, its margin setose; exopod narrow, dorsal margin sinuous, or broad and with a definite dorso-distal lobe. Telson with two basal statocysts, apex with long setae.

Male antenna 1 flagellum with more than 10

isometric articles, bearing numerous aesthetascs; much longer than head.

Type-species: *Apanthuretta pori* Wägele, 1981.

Remarks: Wägele (1981a) first mentioned the name "*Apanthuretta* gen. n." and listed several included species. None was listed as type-species and accordingly the name *Apanthuretta* remained invalid (ICZN Article 13(b)). In a later publication the name was published again as new with a valid type-species (Wägele, 1981b) and this must be taken as its first publication.

The three new Australian species are distinguished by subtle morphological differences in the form of the telson and uropods and in setation of antenna 1. The northern Australian species, *A. coppingeri* Barnard is also a species of *Apanthuretta* (examination of holotype).

Apanthuretta correa sp. nov.

Figures 26, 27

Material examined: 1 male, 11 juveniles; 7.0-9.5 mm:

Holotype: juvenile, 8.3 mm, QMW8460 (with one slide). Qld, Moreton Bay, Bramble Bay (27°18'S., 153°06'E.), Oct 1977 (QUBS station).

Paratypes: Qld, type locality, QMW10003 (4 specimens); Moreton Bay, Bramble Bay, QUBS stations: QMW8453(1) (with one slide); QMW8461(4); NMVJ3212(2).

Description: Integument not pigmented. Eyes present. Head little longer than wide, tapering anteriorly. Antenna 1 peduncle with a single long marginal seta only on article 3, 1 minute seta and marginal brush-setae on both articles 1 and 2. Mandibular palp articles with 1, 2 and 3 setae respectively. Maxilliped article 4 with 2 mesial setae, 1 laterally and 2 distally; article 5 with 5 setae, just exceeding distal margin of article 4.

Pereopod 1 article 4 with 2 mesial setae on anterior margin; article 5 with a strong distal truncate tooth, with 3 mesial stout setae; article 6 twice as long as greatest width, its palm with an obscure step at midpoint, with 8 marginal setae and 10 stout setae on mesial face.

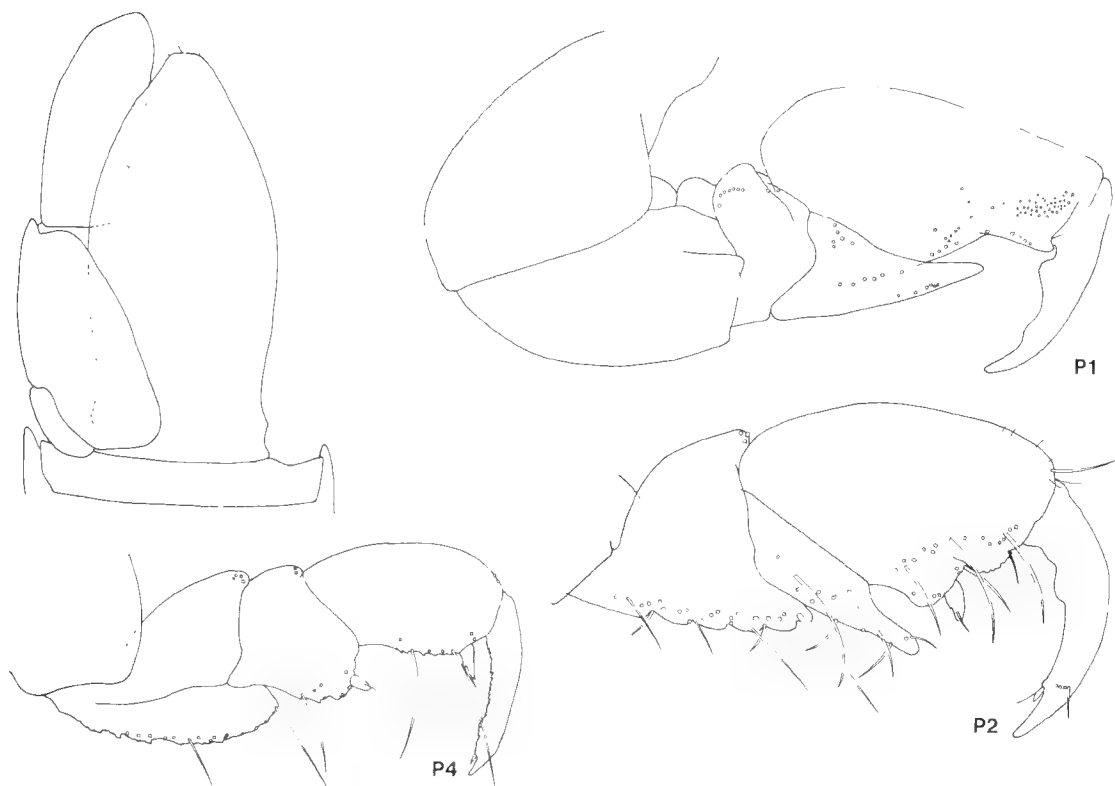


Figure 25. *Apanthura* sp. Male, 12.1 mm, NMVJ3056.

Pereopod 2 article 4 with a convex setose posterior margin; article 5 barely produced distally; article 6 linear, with few mesial setae. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with articles 4-6 having convex posterior margins bearing several long setae.

Uropodal endopod about $1.5\times$ as long as wide, with a continuous row of long setae along lateral and terminal margin; 3 brush-setae on distolateral margin and 3 others dorsally. Exopod $2.3\times$ as long as greatest width, lateral margin most curved in distal half and tapering to rounded apex; 2 pairs of long dorsal setae two-thirds way along and few near apex.

Male: Antenna 1 flagellum of 20 articles, reaching back to posterior margin of pereonite 1. Eyes enlarged. Head with a ventral lobe at base of maxillipeds. Pereopod 1 with longer palm than in juvenile, bearing numerous mesial setae. Other pereopods more elongate than in juvenile. Appendix masculina on pleopod 2 with a terminal hook, extending beyond end of

endopod. Uropodal rami more elongate than in juvenile. Telson tapering more sharply and with fewer setae than in juvenile.

Distribution: *Apanthuretta correa* co-occurs in Moreton Bay with *A. pimelia*; the species is recognised by the absence of long setae on the first two articles of antenna 1 and the strong tooth on article 5 of pereopod 1. The male has a well-developed chin posterior to the base of the maxillipeds.

Apanthuretta olearia sp. nov.

Figures 1b, 28-30

Material examined: 1 male, 8 submales, 362 juveniles; 4.0-13.2 mm:

Holotype: juvenile, 10.3 mm, NMVJ2110 (with one slide), Vic., Port Phillip Bay ($37^{\circ}57.7'S.$, $144^{\circ}44.7'E.$), sand, 5 m, 3 Feb 1972 (PPBES stn 907).

Paratypes: Vic., type locality, NMVJ2111 (1 specimen), NMVJ2112(10), NMVJ2113(1).

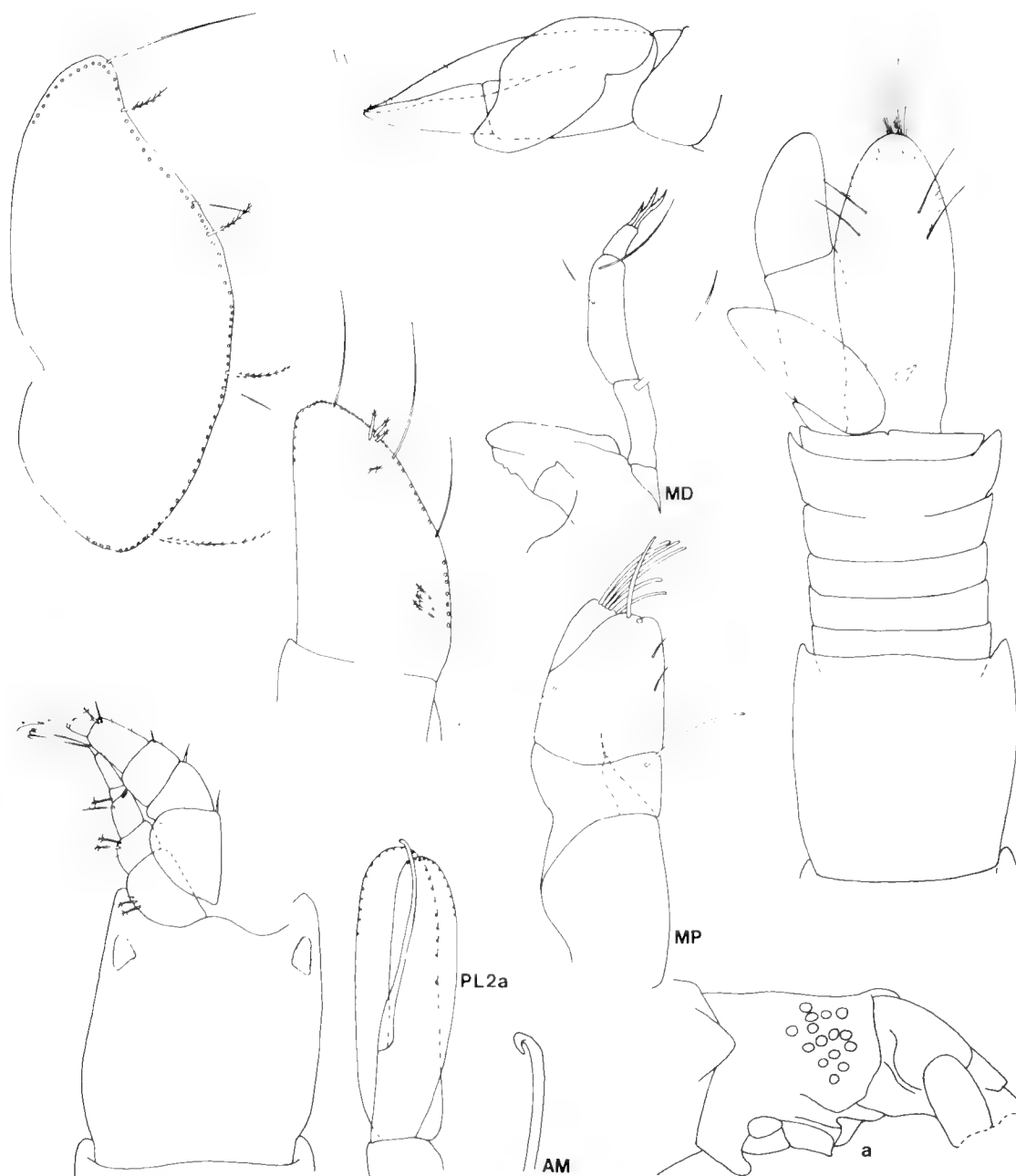


Figure 26. *Apanthuretta correa*. Holotype juvenile, 8.3 mm; a, paratype male, 7.0 mm, QMW8453.

Port Phillip Bay, PPBES stations: stn 931, NMVJ2172(2); stn 944, AMP33568(2); stn 984, NMVJ2114(1); NMVJ2171(1), NMVJ2231(17).

Other material: NSW, Careel Bay, Pittwater, AMP21086(1). E. of Malabar, AMSBS stn III,

AMP22825(1), AMP33569(3); NSW SF stn K80-20-11, AMP32653(2). Port Jackson, AMP33570(1). Botany Bay, 25 specimens from samples collected by D. Dexter: AMP24987, P31040-2, P32646, NMVJ3024, J3025. Port

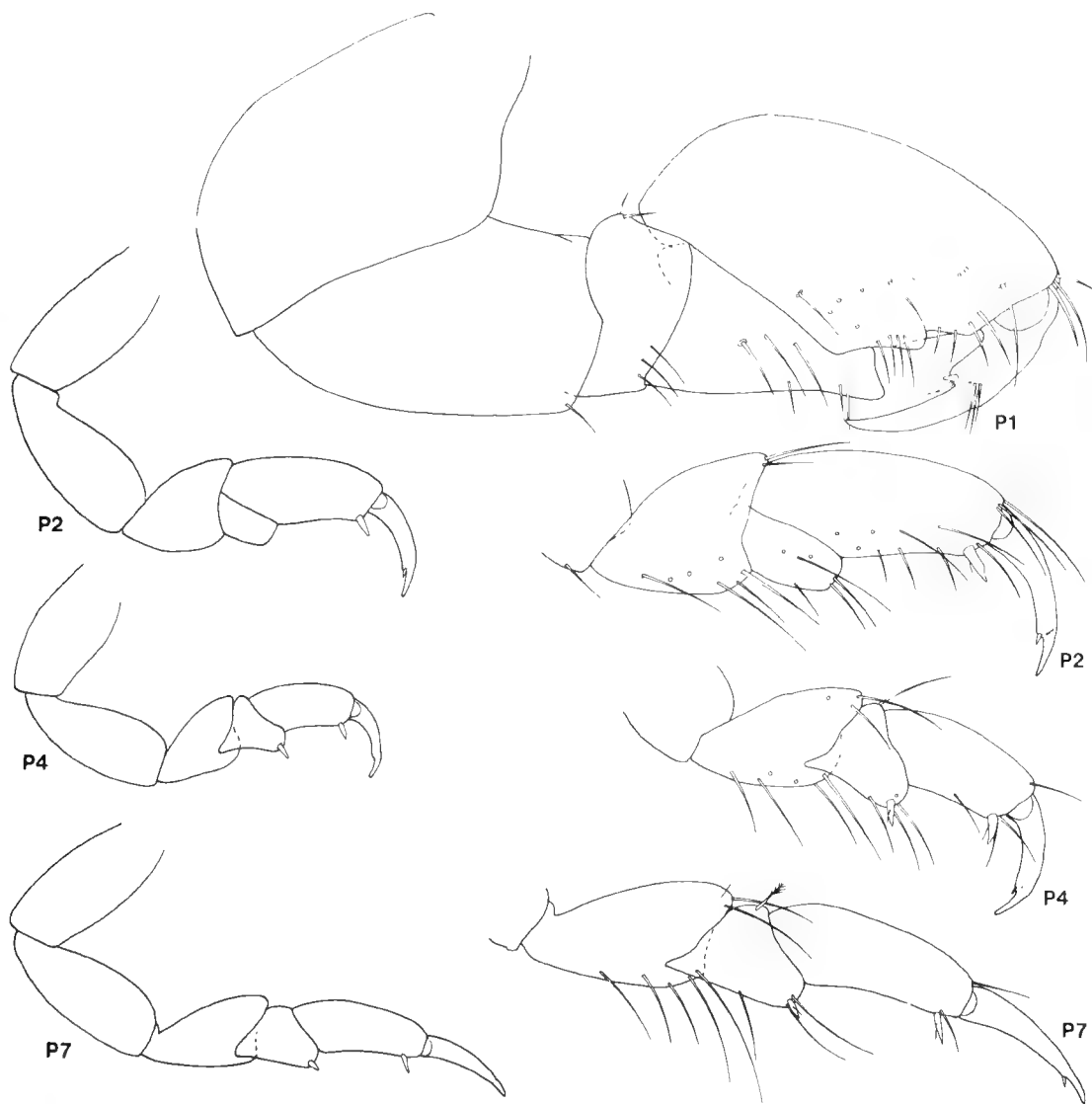


Figure 27. *Apanthuretta correa*. Holotype juvenile, 8.3 mm.

Hacking, Gunnamatta Bay, 12 specimens from CSIRO and NSW SF samples: AMP32542, P32523, P32525, P32679, NMVJ2292, J3026. Jervis Bay, 21 specimens from 7 NSW SF stations, AMP32613, P32616-18, P32623, P32625, P33571-3.

Bass Strait, 40°43.9'S., 148°32.5'E. (BSS stn 163), NMVJ3028(5).

Tas., east coast, 83 specimens from 7 samples

collected by A. J. Dartnall: NMVJ2283-9, TMG2644.

Vic. Port Phillip Bay, 18 specimens from 8 PPBES stations, NMVJ2232-40. Western Port, Crib Point, 149 specimens from 19 CPBS stations, NMVJ2246-82, J3032. Western Port, 14 specimens from 6 WBES stations, NMVJ2240-5.

SA, Kangaroo Island, Kingscote, SAM(1).

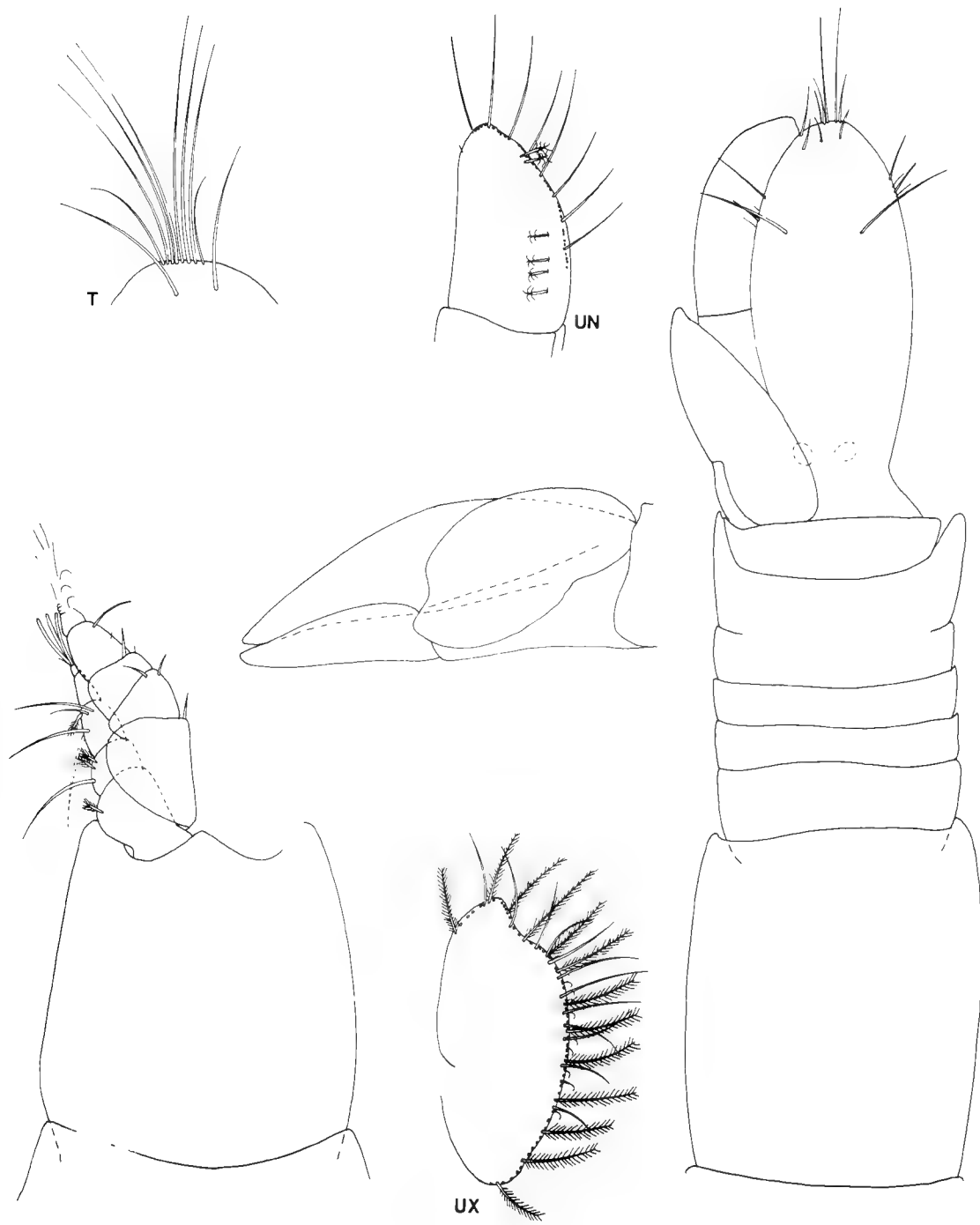


Figure 28. *Apanthuretta olearia*. Holotype juvenile, 10.3 mm.

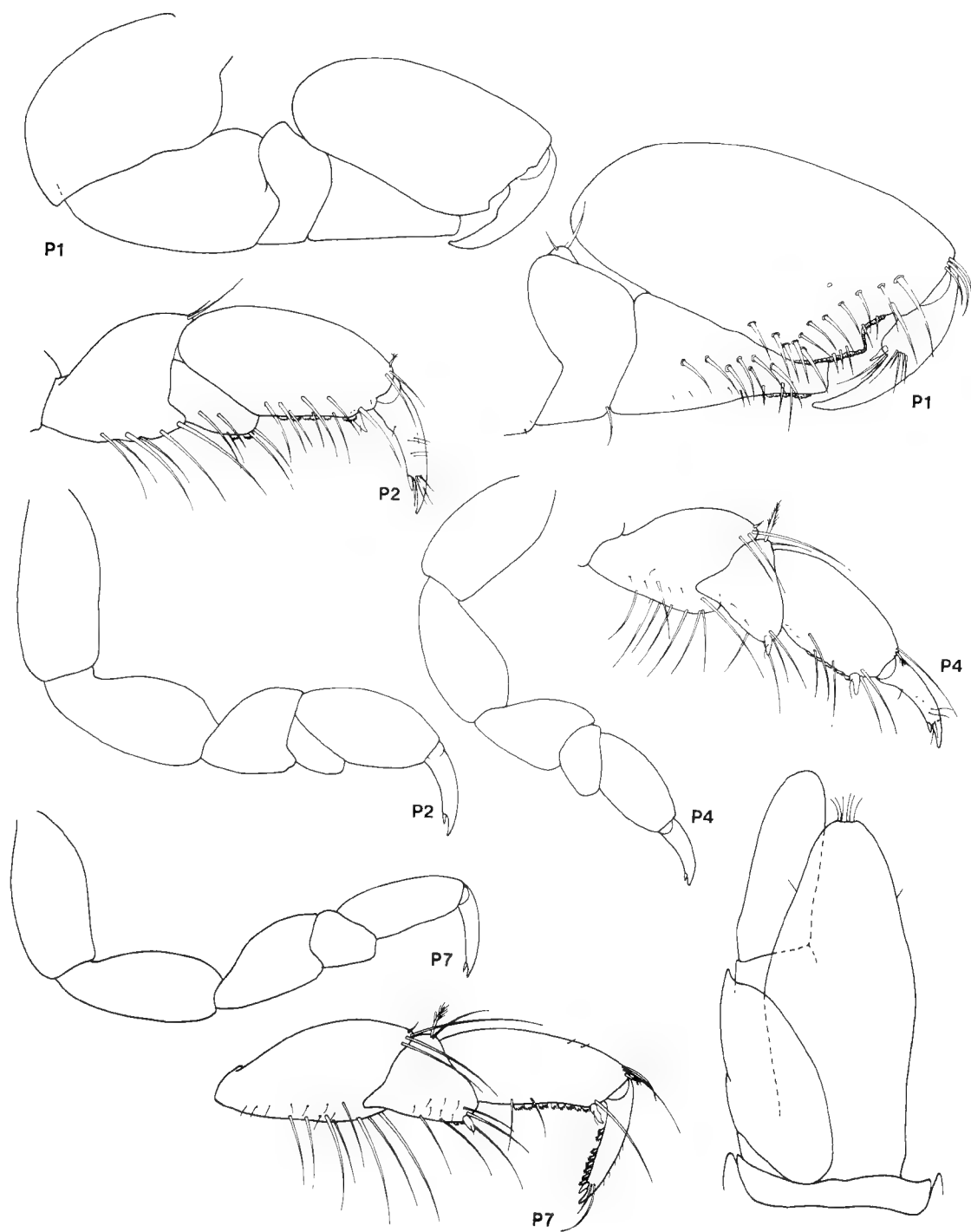


Figure 29. *Apanthuretta olearia*. Holotype juvenile, 10.3 mm; a, paratype male, 10.7 mm, NMVJ2111.

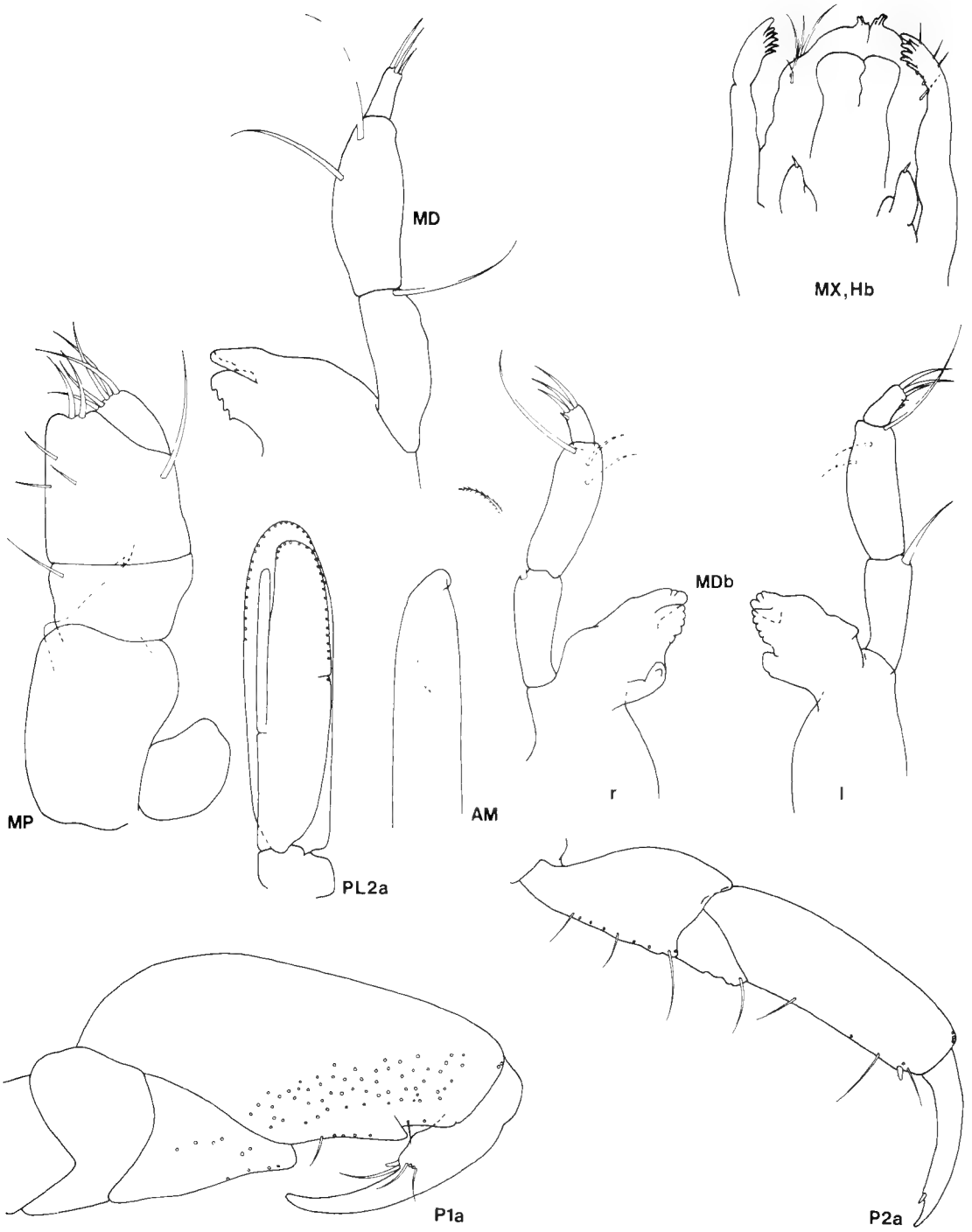


Figure 30. *Apanthuretta olearia*. Holotype juvenile, 10.3 mm; a, paratype male, 10.7 mm, NMVJ2111; b, paratype juvenile, 13.1 mm, NMVJ2114.

Description: Integument not pigmented. Eyes present. Head about as long as wide, tapering anteriorly. Antenna 1 peduncle with a single long marginal seta on each of articles 2 and 3 and with marginal brush-setae on articles 1 and 2. Mandibular palp articles with 1, 3 and 3 setae respectively. Maxilliped article 4 with 3 setae near mesial margin, 1 laterally and 2 distally; article 5 with 5 setae, exceeding distal margin of article 4.

Pereopod 1 articles 4 and 5 each with 1-2 mesial setae along anterior margin; article 5 truncate distally, with 7 mesial stout setae; article 6 twice as long as greatest width, its palm with a pronounced step at midpoint, a marginal row of 6 setae and 12 stout setae on mesial face. Pereopod 2 article 4 with a convex setose posterior margin; article 5 not produced distally; article 6 ovoid, with few mesial setae. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with articles 4-6 having convex posterior margins bearing several long setae.

Uropodal endopod about $1.5\times$ as long as wide, with a continuous row of long setae along lateral and terminal margin; 2 brush-setae on distolateral margin and others dorsally. Exopod $2.3\times$ as long as greatest width, widest distally, distal lobe short and acute, dorsal margin concave only distally. Telson almost as long as pleon, $2.4\times$ as long as greatest width, lateral margins evenly convex (barely more sharply curved at midpoint and tapering to a broadly rounded apex; evenly domed in longitudinal section; 2 long dorsal setae three-quarters way along and few near apex; lateral setae only on distal third.

Male: Antenna 1 flagellum of 28 articles, reaching back to middle of pereonite 3. Eyes enlarged. Pereopod 1 with longer palm than in juvenile, bearing numerous mesial setae, palmer tooth more pronounced and more distal. Other pereopods, especially pereopod 2, more elongate than in juvenile; article 6 of pereopod 2 linear. Appendix masculina on pleopod 2 simple, not reaching to end of endopod. Uropodal rami narrower than in juvenile and extending well beyond end of telson. Telson tapering more sharply and with fewer setae than in juvenile.

Distribution: Southern New South Wales, Victoria, Tasmania and South Australia, intertidal to 56 m.

Remarks: *Apanthuretta olearia* is the most abundant and widespread species of the *Apanthura*-complex from south-eastern Australia. The presence of a single lateral long seta on the second article of antenna 1 and broader telson distinguish it from other species.

Apanthuretta pimelia sp. nov.

Figures 31-33

Material examined: 2 males, 3 submales, 56 juveniles, 5.1-13.2 mm:

Holotype: juvenile, 13.2 mm, QMW10004 (with one slide). Qld, Moreton Bay, Middle Banks ($27^{\circ}25'S.$, $153^{\circ}20'E.$), Jun 1973 (QUBS station).

Paratypes: Qld, Moreton Bay, QUBS stations: QMW10006 (with one slide) (1 specimen), QMW10005(5), QMW6126 (with one slide)(1), QMW6128(1), QMW8132(1), QMW8281(2), QMW8454(6), QMW8455(1), QMW8458(2), NMVJ2290(5), NMVJ2291(6), AMP33590(4), AMP33591(3).

Other material: Qld, Moreton Bay, QUBS stations, QMW10007-16(21 specimens).

NSW, Off Belmont Beach, HDWBS station, AMP24367(1).

Description: Integument not pigmented. Eyes present. Head almost as long as wide, tapering anteriorly. Antenna 1 peduncle with 2, 3 and 1 long marginal setae on articles 1, 2 and 3 respectively, and with marginal brush-setae on articles 1 and 2. Mandibular palp articles with 1, 5 and 3 setae respectively. Maxilliped article 4 with 3 mesial setae, 2 near mesial margin, 1 laterally and 2 distally; article 5 with 6 setae, just exceeding distal margin of article 4.

Pereopod 1 articles 4 and 5 each with 1-2 mesial setae along anterior margin; article 5 truncate distally, with 7 mesial stout setae; article 6 $2.5\times$ as long as greatest width, its palm with pronounced step at midpoint, a marginal row of 7 setae and 16 stout setae on mesial face. Pereopod 2 article 4 with a convex setose posterior margin; article 5 scarcely produced distally; article 6 ovoid, with few mesial setae, with a distal spine on posterior margin.

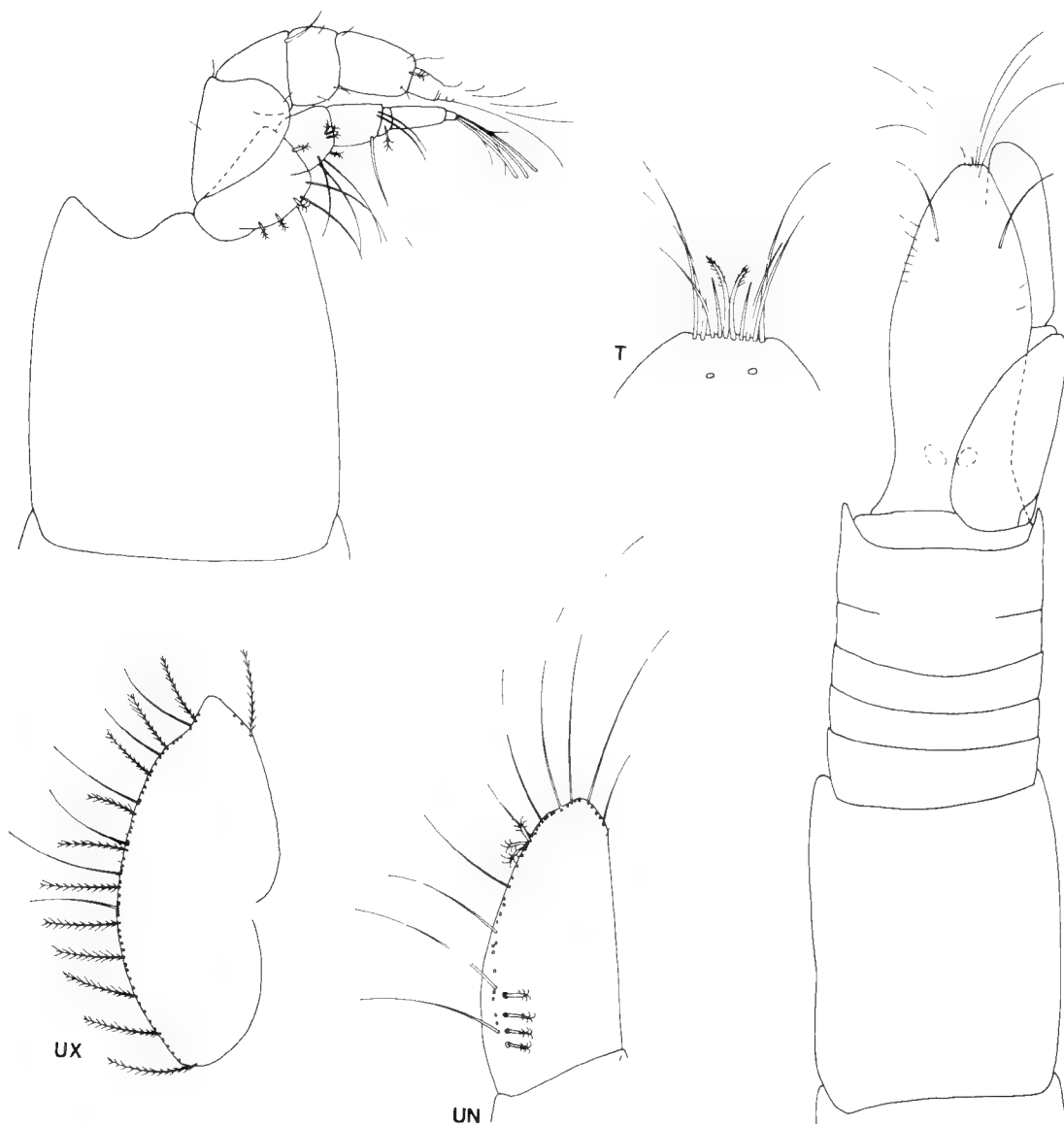


Figure 31. *Apanthuretta pimelia*. Holotype juvenile, 13.2 mm.

Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with articles 4-6 having convex posterior margins bearing numerous long setae.

Uropodal endopod almost twice as long as wide, with a continuous row of long setae along lateral and terminal margin; 3 brush-setae on distolateral margin and others dorsally. Exopod $2.3\times$ as long as greatest width, widest at midpoint, distal lobe acute, dorsal margin evenly convex and barely concave distally. Telson

almost as long as pleon, $2.4\times$ as long as greatest width, lateral margins evenly convex and tapering sharply to a truncate apex; 1 pair of dorsal setae near apex and another pair three-quarters way along.

Male: Antenna 1 with flagellum of about 23 articles, whole about $7\times$ as long as head. Eyes enlarged. Pereopod 1 with longer palm than in juvenile, bearing numerous mesial setae rather than spines, palmar tooth more produced.

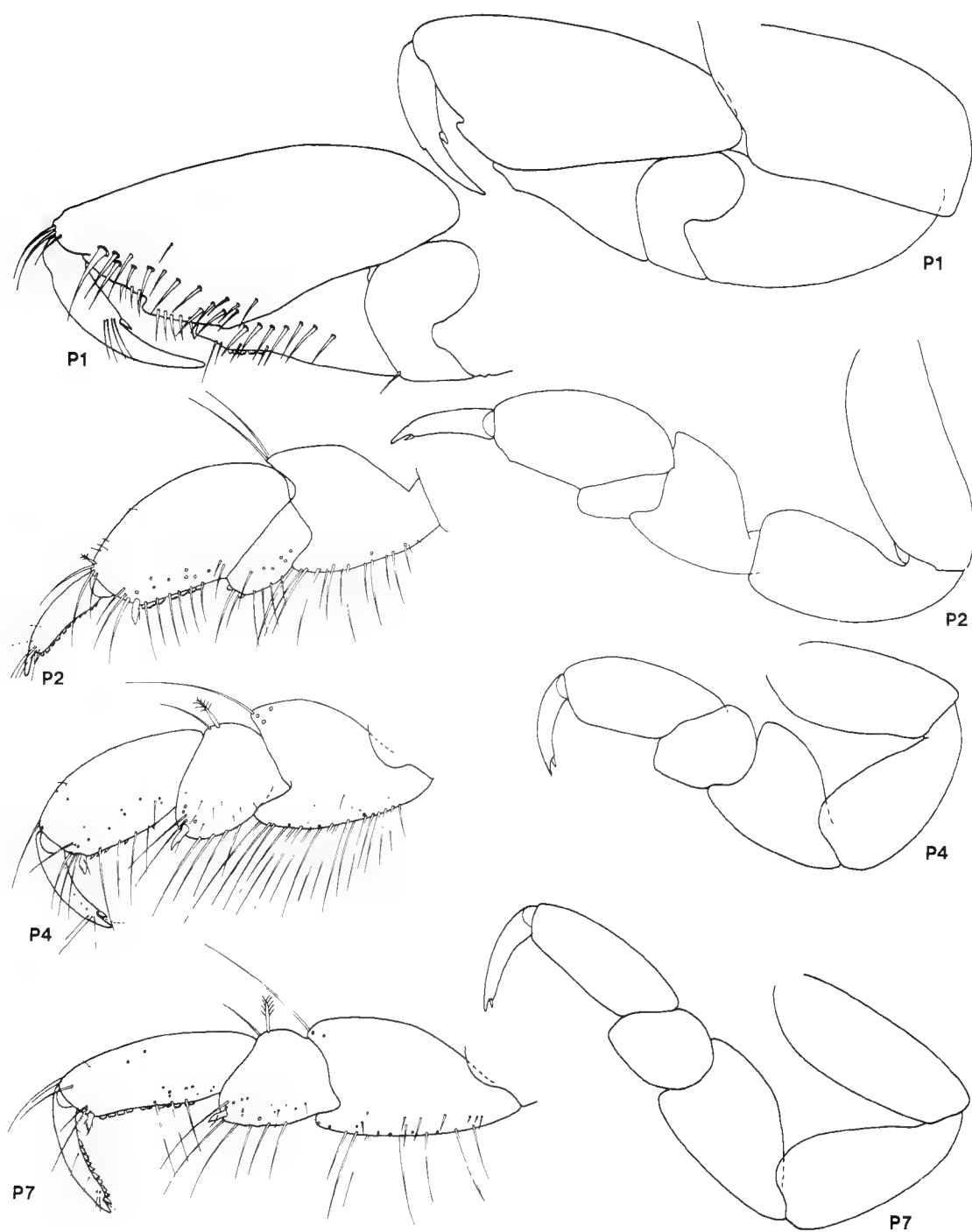


Figure 32. *Apanthuretta pimelia*. Holotype juvenile, 13.2 mm.

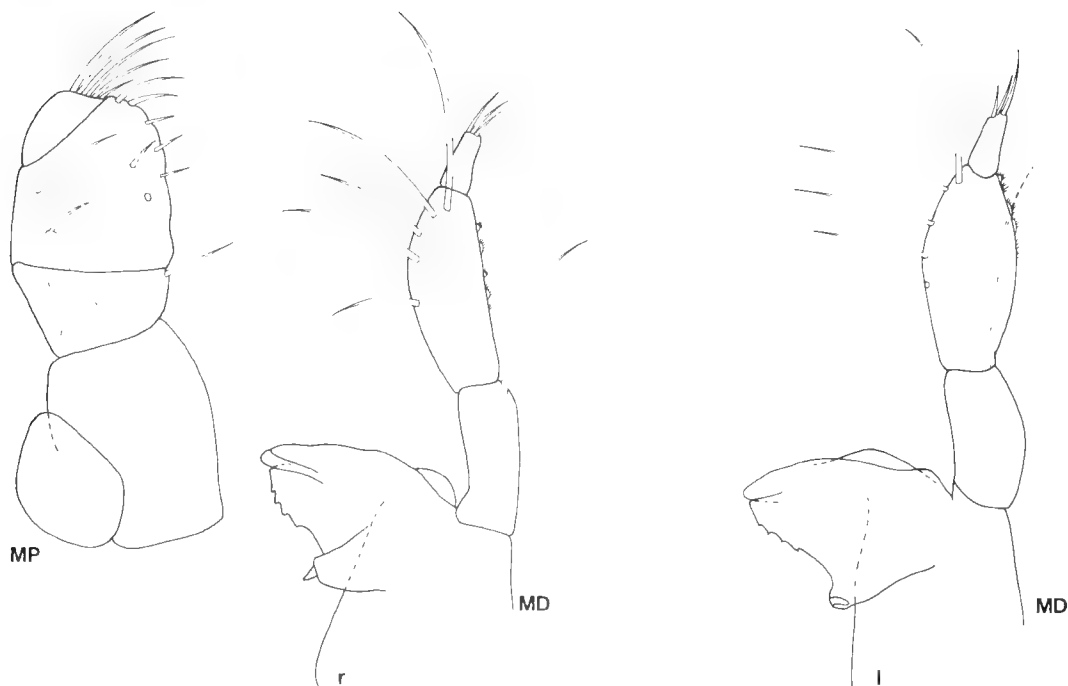


Figure 33. *Apanthuretta pimelia*. Holotype juvenile, 13.2 mm; l, left; r, right.

Other pereopods with article 6 more elongate than in juvenile. Appendix masculina on pleopod 2 simple, reaching to end of endopod. Uropodal endopod narrower, extending well beyond end of telson. Telson widest in proximal half and tapering more sharply than in juvenile.

Distribution: Southern Queensland and northern New South Wales; shelf and bays.

Remarks: *Apanthuretta pimelia* is a more elongate species than others from Australia. The sixth article of pereopod 1 is especially narrow but distal articles of the walking legs are broader and more setose than in *A. correa* with which it co-occurs.

***Apanthuropsis* gen. nov.**

Diagnosis: Integument smooth, pigmentation not known. Eyes present. Antenna 1 flagellum short, of 3 articles, the last minute and bearing 3 aesthetascs. Antenna 2 flagellum short with 4 articles. Mandibles asymmetrical, not sexually dimorphic; incisor, short lamina dentata and molar present (molar of right side with a tooth fitting into a socket on molar of left side); palp

3-articled, article 3 one-third length of article 2, with 3 terminal setae. Maxilliped without an endite, of five articles; article 3 longer than wide; article 4 without mesial setae; article 5 subterminal, oblique, much smaller than 4, with 5 terminal setae.

Pereopod 1 subchelate; article 6 swollen, palm very short, stepped (not toothed) and lacking mesial spines. Pereopods 2 and 3 article 6 swollen, with short dactyl. Pereopods 4-7 with triangular-trapeziform article 5, its anterior margin free.

Pleon longer than pereonite 7, as long as wide; pleonites 1-5 fused; pleonite 6 free from others but fused to telson. Pleopod 1 exopod operculiform, endopod setose; pleopods 2-5 setose. Uropodal endopod shorter than peduncle, with a setose margin; exopod dorsally sinuous but not excavate. Telson with 2 basal statocysts, apex with long setae.

Male antenna 1 flagellum with about 20 articles bearing numerous aesthetascs, reaching posterior margin of pereonite 2.

Type-species: *Apanthuropsis richea* sp. nov.

***Apanthuopsis richea* sp. nov.**

Figures 1c, 34-37

Material examined: 1 male, 11 juveniles; 5.6-8.4 mm:

Holotype: juvenile, 5.9 mm, NMVJ2299 (with one slide). Vic., Western Port, Crib Point (38°21'S., 145°14'E.), 11 m, Marine Studies Group, 26 Aug 1964 (CPBS stn C3).

Paratypes: Vic., Western Port, Crib Point, CPBS stations: stn C2, NMVJ2300 (1 specimen); stn 23S, NMVJ2301(1); stn 32S, NMVJ2302(1); stn 33N, NMVJ2303(1); stn 41N, NMVJ2304(1); stn 21N (1973), NMVJ2305(1), NMVJ2306(1), NMVJ2916 (1 male); stn 32N (Apr 1968), NMVJ2307(1). Western Port, WBES stn 1730, AMP33588 (1). **Other material:** Vic., Western Port, Crib Point, CPBS stn 32N (Aug 1970), NMVJ2308(1).

Description: Integument not pigmented. Eyes present. Head about as long as wide, lateral margins convex, rostrum broadly rounded. Antenna 1 peduncle with 1 long marginal seta on article 2 and with marginal brush-setae on articles 1 and 2. Mandibular molar with a blunt tooth on the right side, fitting into a socket on the left side; lamina dentata with 4 teeth; incisor blunt; palp articles with 1, 1 and 3 setae respectively. Maxilliped with no endite, article 3 with 1 seta near distomesial corner; article 4 with 1 submesial seta, 1 laterally and 1 distally; article 5 with 5 setae, just exceeding distal apex of article 4.

Pereopod 1 articles 4 and 5 each with 1-2 mesial setae along anterior margin; article 5 truncate distally; article 6 about $1.7\times$ as long as greatest width, its short palm with pronounced step at midpoint, 6 marginal setae and 8 fine setae on mesial face; article 7 basally very broad, supplementary claw on a lobe at base of unguis. Pereopod 2 article 4 with 5 anterior setae, not posteriorly lobed; article 5 without posterior tooth; article 6 broadly ovoid, mesially sparsely setose, with a distal spine on posterior margin; dactyl distally densely setose. Pereopod 3 similar to 2, but smaller. Pereopods 4-7 with articles 4-6 having convex posterior

margins bearing few long setae, dactyl distally densely setose.

Uropodal endopod with a continuous row of long setae along lateral and terminal margin; 6 brush-setae dorsally. Exopod $2.0\times$ as long as greatest width, distal lobe broadly rounded; dorsal margin almost evenly convex.

Telson as long as pleon, $2.1\times$ as long as greatest width, lateral margins abruptly curved two-thirds way along and tapering sharply from there to an acutely-rounded apex; dorsal setae in 2 submarginal rows on distal third.

Male: Antenna 1 with flagellum of 20 articles reaching back to posterior margin of pereonite 2. Eyes enlarged; head wider anteriorly; rostrum more pronounced than in juvenile and with a dorsal depression. Pereopod 1 similar to that of juvenile except palmar tooth more pronounced and mesial setae more numerous. Other pereopods more elongate than in juvenile. Appendix masculina on pleopod 2 a simple rod reaching just beyond end of endopod. Uropodal rami not modified. Telson broader than in juvenile and more abruptly tapering; strongly concave dorsally and sharply deflexed at tip.

Distribution: Western Port, Victoria, muddy and gravelly sand sediments, 8-14 m.

Remarks: The relationship of the genus *Apanthuopsis* to *Apanthura* and *Apanthuretta* was discussed above. Its only known species is quickly distinguished from species of the other genera by similar ovoid form of the first three pereopods.

Acknowledgements

This contribution was made possible through a grant from the Australian Biological Resources Study. We are especially grateful to G. Milledge who inked all the figures. For the loan of material we thank J. Lowry (Australian Museum), W. Zeidler (South Australian Museum), A. Green (Tasmanian Museum), R. Green (Queen Victoria Museum), P. Davie (Queensland Museum), S. Cook (University of Queensland) and S. Rainer (CSIRO, Cronulla), and the numerous individuals who provided material to museums for taxonomic study.

The collections of the Bass Strait Survey and at Cape Paterson were made possible by a

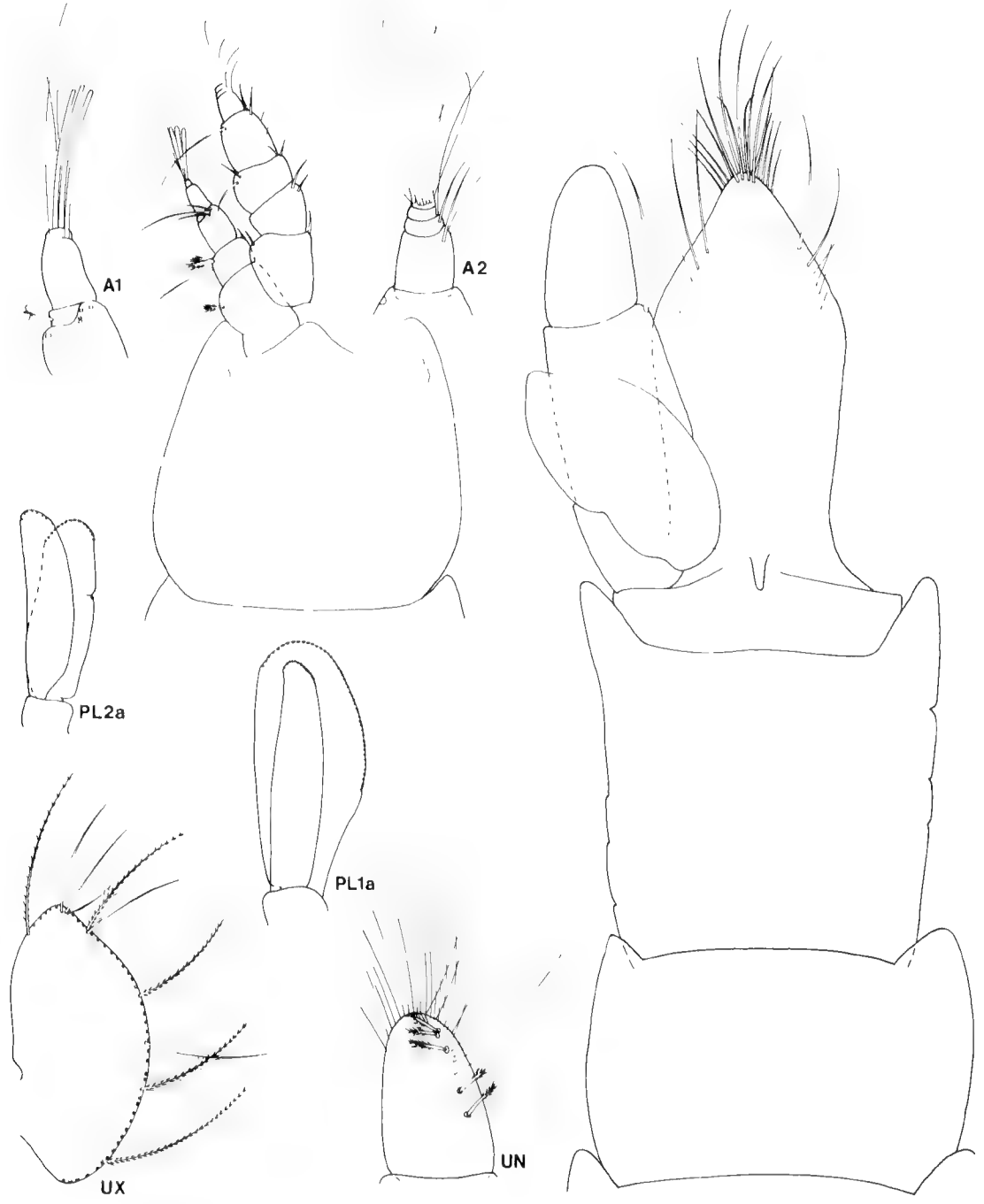


Figure 34. *Apanthuropsis richea*. Holotype juvenile, 5.9 mm.

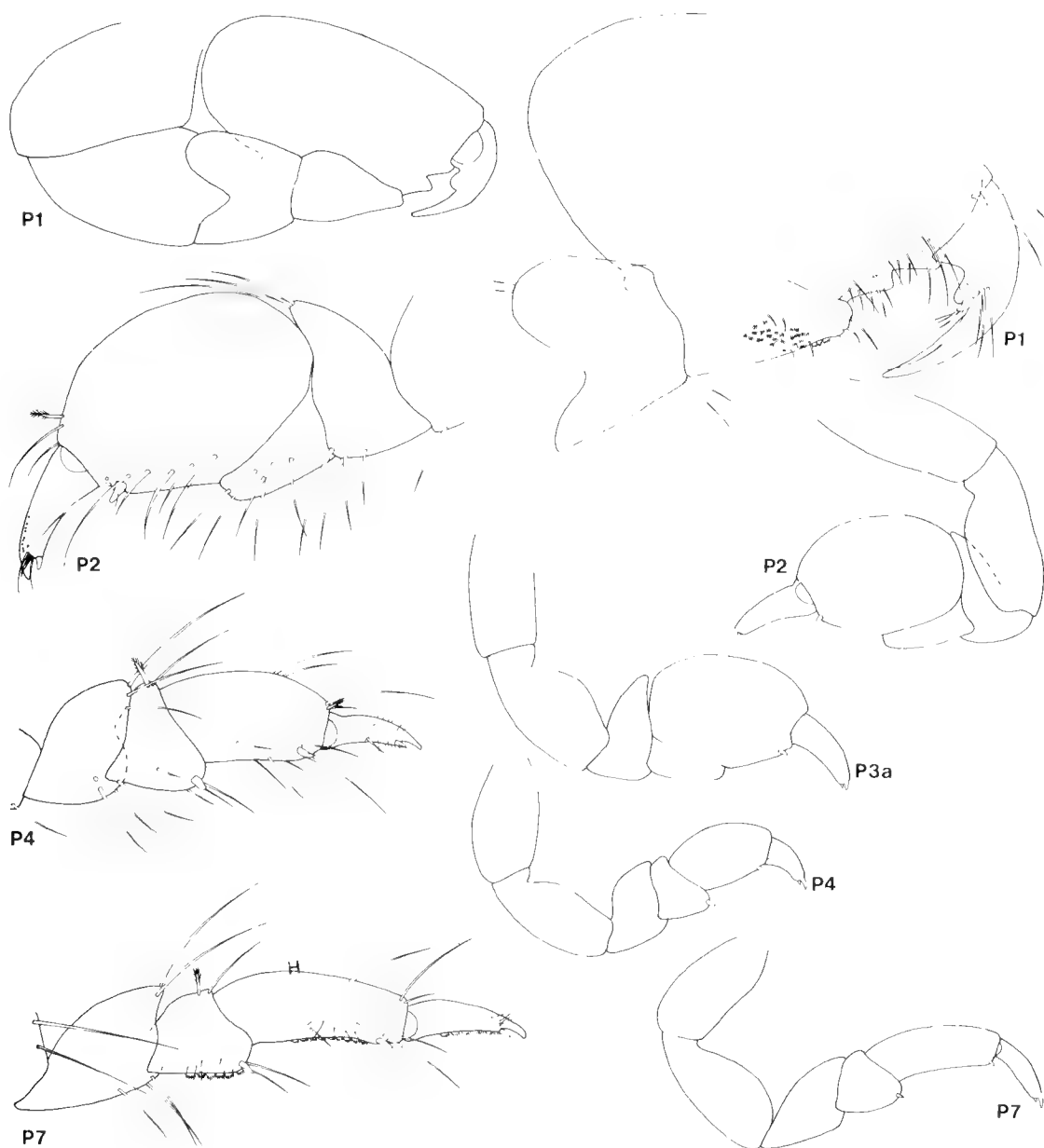


Figure 35. *Apanthuopsis richea*. Holotype juvenile, 5.9 mm; a, paratype juvenile, 8.4 mm, NMVJ2305.

Marine Sciences and Technologies grant to the National Museum of Victoria. We are indebted to the Department of Science and Technology for this support and to R. Wilson for processing the samples.

References

- BARNARD, K. H., 1925. A revision of the family Anthuridae (Crustacea Isopoda), with remarks on certain morphological peculiarities. *J. Linn. Soc.* 36: 109-60.
- HASWELL, W. A., 1881. On some new Australian marine Isopoda. Part I. *Proc. Linn. Soc. N.S.W.* 5: 470-81.

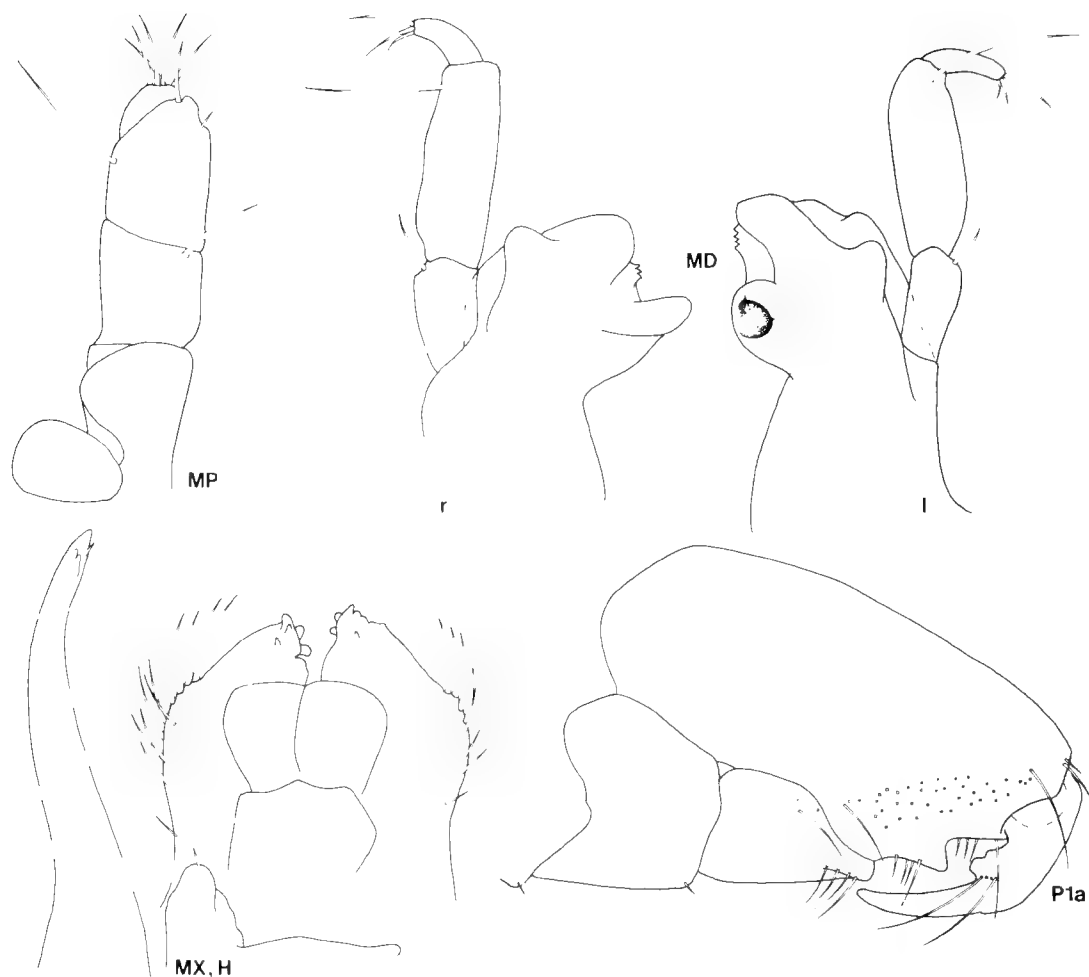


Figure 36. *Apanthuropsis richea*. Paratype juvenile, 10.5 mm, NMVJ2304; a, paratype male, 10.1 mm, NMVJ2916; l, left; r, right.

- KENSLEY, B., 1980. Anthuridean isopod crustaceans from the International Indian Ocean Expedition, 1960-1965, in the Smithsonian. *Smithson. Contr. Zool.* 304: 1-37.
- KRUCZYNSKI, W. L. & MYERS, G. J., 1976. Occurrence of *Apanthura magnifica* Menzies and Frankenberg, 1966 (Isopoda: Anthuridae) from the west coast of Florida, with a key to the species of *Apanthura* Stebbing, 1900. *Proc. biol. Soc. Wash.* 89: 353-60.
- POORE, G. C. B., 1975. Australian species of *Haliophasma* (Crustacea: Isopoda: Anthuridae). *Rec. Austr. Mus.* 29: 503-33.
- POORE, G. C. B., 1978. *Leptanthura* and new related genera (Crustacea, Isopoda, Anthuridea) from eastern Australia. *Mem. natn. Mus. Vict.* 39: 135-69.
- POORE, G. C. B., 1981. Paranthurid isopods (Crustacea, Isopoda, Anthuridea) from southeastern Australia. *Mem. natn. Mus. Vict.* 42: 57-88.
- POORE, G. C. B., 1984. *Paranthura* (Crustacea, Isopoda, Paranthuridae) from south-eastern Australia. *Mem. Mus. Vict.* 45: 33-69.
- STEBBING, T. R. R., 1900. On Crustacea brought by Dr Willey from the South Seas. In A. Willey, *Zoological Results* 5: 605-90.
- TUBB, J. A., 1937. Lady Julia Percy Island: Report of the expedition of the McCoy Society for Field Investigation and Research. No. 18. Crustacea. *Proc. R. Soc. Vict.* 49: 408-11.
- WÄGELE, J. W., 1980. Anthuridea (Crustacea, Isopoda) aus dem Tyrrhenischen Meer. *Zoologica Scr.* 9: 53-66.
- WÄGELE, J. W., 1981a. Zur Phylogenie der Anthuridea (Crustacea, Isopoda) mit Beiträgen zur Lebensweise, Morphologie, Anatomie und Taxonomie. *Zoologica, Stuttg.* 132: 1-127.
- WÄGELE, J. W., 1981b. Study of the Anthuridae (Crustacea: Isopoda: Anthuridea) from the Mediterranean and the Red Sea. *Israel J. Zool.* 30: 113-59.

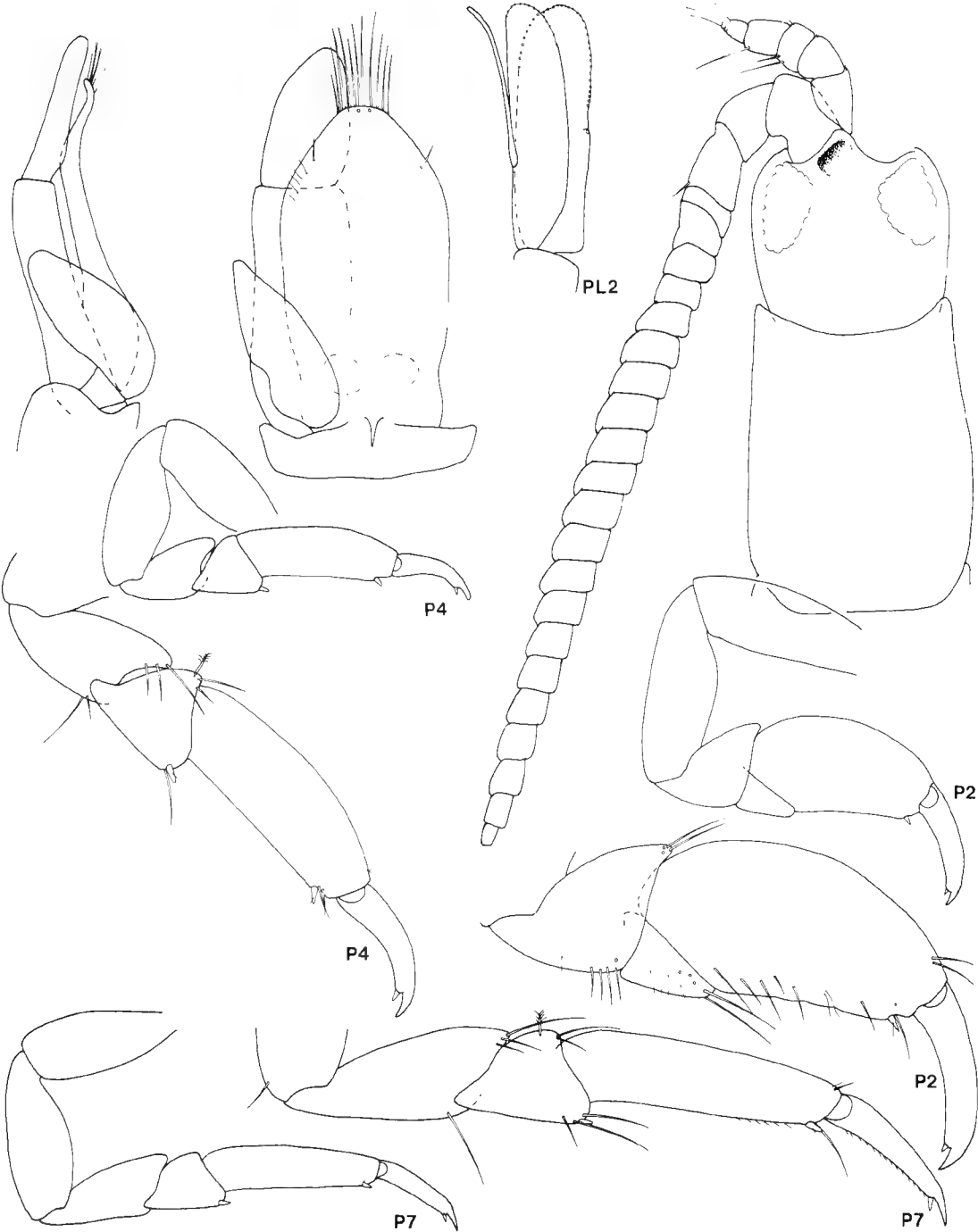


Figure 37. *Apanthuopsis richea*. Paratype male, 10.1 mm, NMVJ2916. Aesthetascs on antenna 1 not figured.

AUSTRALIAN CHAETILIIDS (CRUSTACEA: ISOPODA: VALVIFERA): A NEW GENUS, NEW SPECIES AND REMARKS ON THE FAMILY

BY GARY C. B. POORE

Department of Crustacea, Museum of Victoria, Russell Street, Melbourne, Victoria 3000, Australia

Abstract

The family Chaetiliidae (Isopoda) is redefined to include all genera not included in the idoteid subfamily Idoteinae and previously included in its other four subfamilies (Chaetiliinae, Glyptonotinae, Mesidoteinae and Parachiridoteinae). Three Australian genera, *Austrochaetilia* Poore, *Chaetilia* Dana and *Stegidotea* gen. nov., are defined and new species, *C. tasmanica*, *S. pinnata* and *S. scabra*, described.

Introduction

The valviferan isopod family Idoteidae Fabricius, 1798, has been divided at various times into five subfamilies: Idoteinae Dana, 1853; Chaetiliinae Dana, 1853 (= Macrochiridotheinae Nordenstam, 1933); Glyptonotinae Miers, 1881; Mesidoteinae Racovitza & Sevestos, 1910; and Parachiridoteinae Elkaim & Daguerre de Hureaux, 1976. The separation of the Idoteinae from the rest is clear and well-documented by Brusca (1984) in his analysis of the phylogeny, evolution and biogeography of idoteine genera. A simple tabulation of the characters of non-idoteine genera suggested that in fact more than one alternative subfamily is not justified and that this group rates family status as implied by Bowman and Abele (1982).

The non-idoteines, which Brusca called the "glyptonotine-group", are here all included in the Chaetiliidae. The family-group name first applied to these genera was Chaetilidae Dana, 1853, its spelling corrected for the first time by Miers (1881). The group is distinguished by the synapomorphies: head strongly produced laterally, moving eyes to a dorsal position; body broadened and dorsoventrally depressed; and pereopods 1-3 (at least) subchelate or prehensile. The group retains the symplesiomorphies of four free pleonites (in primitive genera), two uropodal rami, and separate penes. A list of genera of the Chaetiliidae was given by Poore (1984). To this list of available names must be added *Idotoeaga* Lockington, 1877, and *Saussureana* Haller, 1879, both probable junior synonyms of *Saduria* Adams (Miers, 1881). Another is added here. Poore (1984) also rediagnosed in detail *Macrochiridothea* Ohlin and *Symmius* Richardson. The

name *Macrochiridothea* Ohlin was published in 1907, not 1901 as frequently given.

The initial objective of this paper, to describe new forms from Bass Strait and Tasmania, necessitates some comment on the status of the family but detailed analysis of the relationships between genera is left for some other time. At present many genera are too poorly known to allow for sensible comment. The genera display many convergences which will require a detailed and thorough analysis.

Successive definitions of the subfamily Chaetiliinae (Nordenstam, 1933; Menzies, 1952; Hurley and Murray, 1968; Poore, 1978; Jones and Fenwick, 1978) have become more encompassing, to the point that the Glyptonotinae must be included within it. These two subfamilies are separated from the Mesidoteinae and Parachiridoteinae only on the number of dorsal coxal plates present. However, the reliability of this character in idoteid phylogeny was critically questioned by Brusca and Wallerstein (1979). The division of genera into two groups on the basis of the arrangement of dorsal coxal plates is not straightforward as exemplified by differences between species of *Macrochiridothea* Ohlin. In addition, many parallelisms and convergences result from this dichotomy. For example, in both groups there is a tendency for fusion of pleonites, fusion of maxillipedal palp articles and loss of the tritritive molar process. No character is immediately obvious in supporting this dichotomy.

The Parachiridoteinae was separated from the Mesidoteinae on the basis of natatory pereopods 4 and 5 (Elkaim and Daguerre de Hureaux, 1976). However, this condition is ap-

proached in *Maoridotea* Jones & Fenwick and in all other respects *Parachiridotea* Daguerre de Hureaux & Elkaim is a typical chaetiliid. Kussakin (1979, pp. 75-77) briefly discussed the relationships of the idoteid subfamilies and commented on the geographical distribution of each.

In the following systematic section the Chaetiliidae is redefined. *Chaetilia*, *Austrochaetilia* and a new genus are diagnosed, and three new species described. The material studied here comes largely from sampling in Bass Strait as part of the Museum of Victoria's Bass Strait Survey (BSS stations) and is lodged in its collections, previously those of the National Museum of Victoria (NMV). Small collections are also in the Australian Museum, Sydney (AM) and the Tasmanian Museum and Art Gallery, Hobart (TM). In all figures these abbreviations are used: A1, A2, antennae 1 and 2; P1-P7, pereopods 1-7; PL1-PL5, pleopods 1-5; MD, mandible; MP, maxilliped; MX1, MX2, maxillae 1 and 2; U, uropod. Lower case letters indicate figures from different individuals.

Chaetiliidae Dana

Chaetiliidae Dana, 1853: 711.

Chaetiliidae.—Miers, 1881: 2.—Bowman & Abele, 1982: 19.

Glyptonotinae Miers, 1881: 9.—Nordenstam, 1933: 103.—Sheppard, 1957: 164.

Mesidoteinae Racovitza & Sevestos, 1910: 194-9.

Macrochiridotheinae Nordenstam, 1933: 104-5.—Sheppard, 1957: 168-9.

Chaetilininae Menzies, 1962: 96.—Hurley & Murray, 1968: 243.—Jones & Fenwick, 1978: 617-18.—Poore, 1978: 113-4.

Parachiridoteinae Elkaim & Daguerre de Hureaux, 1976: 275-93.

Diagnosis: Head laterally expended, often laterally incised, immersed in first pereonite. Eyes more or less dorsal, if present. Body broadened and dorsoventrally flattened. Pereopods 1-3 at least, and sometimes 1-5, subchelate or prehensile. Penes separate. Uropod with two rami.

Type-genus: *Chaetilia* Dana, 1853.

Austrochaetilia Poore

Austrochaetilia Poore, 1978: 114.—Jones & Fenwick, 1978: 619.

Diagnosis: Head immersed only slightly in pereonite 1, laterally expanded, margins entire. Eyes dorsolateral, weak. Pereonites 5-7 only with coxal plates distinct dorsally. Pereonite 7 only little narrower than pereonite 6. Pleonites 1-3 completely free, pleonite 1 much narrower than following pleonites, pleonite 4 free only laterally. Pereopods 1-3 prehensile, elongate-ovate article 6 cupped by triangular articles 4 and 5, first only little longer than others. Pereopods 4-7 ambulatory, pereopod 6 only fractionally the longest; all pereopods with a dactyl. Mandible with blunt rounded incisor, lacinia mobilis and spine row reduced, molar an elongate flat plate with setae anterolaterally. Maxillipedal palp of 5 articles, about 1.5 times as long as endite, the penultimate article proximally constricted. Pereopods and antennae ornamented with numerous clubbed setae plus spines on posterior margins of prehensile limbs. Uropods overlapping, enclosing pleopods, but not locking together.

Type-species: *Austrochaetilia capeli* Poore, 1978 (original designation).

Remarks: This diagnosis expands on that presented earlier. In the following remarks dealing with new material of the type-species some important corrections are made which bear on the generic diagnosis. The genus is monotypic.

Austrochaetilia shares with *Saduriella* Holthuis and *Chiridotea* Harger three free pleonites and pleonite 4 fused mid-dorsally. But in the last two genera the lateral margin of pleonite 4 is short or absent and coxae 2-7 are visible dorsally. *Austrochaetilia* is possibly closest to *Glyptonotus* Eights, which differs in having four free pleonites and possessing a cylindrical molar.

Austrochaetilia capeli Poore

Figure 1, Plate 34a.

Austrochaetilia capeli Poore, 1978: 114-18, figs. 1-4.

Material examined: Vic., 20-30 km off Cape

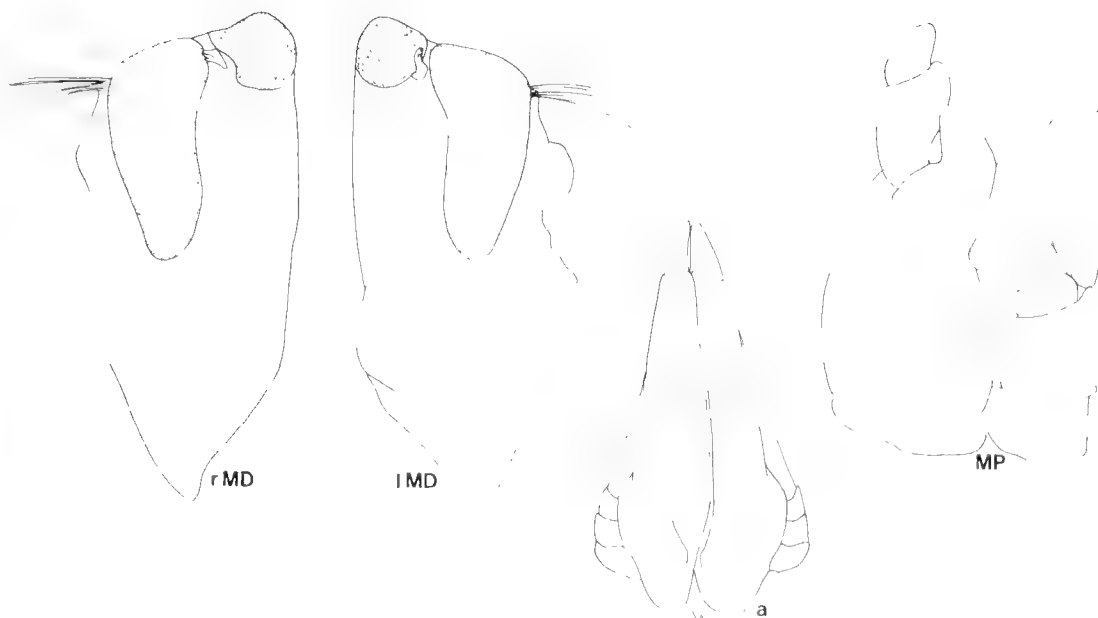


Figure 1. *Austrochaetilia capeli*. Female, 11.4 mm, NMVJ4119. a, ventral view of uropods.

Otway (39°01'-39°08'S., 143°15'-143°36'E.), fine sand, 77-95 m; BSS stn 118 (3 specimens), stn 119(4), stn 120 (6, 3.7-11.4 mm), stn 121(1), NMVJ4116-4120. Flinders, S. W. Fulton and F. E. Grant, no date, NMVJ4121(6, 8.0-12.5 mm). Shoreham, J. A. Kershaw, 30 Mar 1902, NMVJ4122 (1, 11.1 mm).

NSW, Belmont Beach, AMP24062(1), P24063(1).

Distribution: New South Wales and Victorian coast including Port Phillip Bay (not Western Port), sandy sediment, 4-95 m.

Remarks: In the original description two errors were made: an extra suture was figured for antenna 1 and the basal article of the maxillipedal palp was omitted. Re-examination of the mandibles shows that the lacinia mobilis is present. The molar plates appear not to oppose each other and carry laterally a row of molar setae (plate 34a). The mandibles dominate the mouthparts. The lateral sutures separating coxae 2-4 are clearly visible on the ventral surface as illustrated for other genera in this paper.

The new material extends the range of this species both geographically (to NSW) and to greater depth. The species appears not to be widespread in Bass Strait. The sculpture on the

material from Flinders is more pronounced than in the type material.

Chaetilia Dana

Chaetilia Dana, 1853: 711.—Menzies, 1962: 103.—Jones & Fenwick, 1978: 619.

Diagnosis: Head laterally expanded or not, margins incised or entire. Eyes dorsolateral, well-developed. Pereonites 5-7 only with coxal plates distinct dorsally. Pereonite 7 much narrower than pereonite 6. Pleonites 1-3 completely free, pleonite 1 much narrower than following pleonites, as wide as pereonite 7, no pleonites partially free. Pereopods 1-3 subchelate, ovate article 6 cupped proximally by triangular articles 4 and 5. Pereopods 4 and 5 prehensile, article 6 elongate, articles 4 and 5 more or less quadrate. Pereopod 6 elongate, reaching beyond end of pleotelson. Pereopod 7 short (about as long as 5), with a minute dactyl. Mandible with toothed incisor, large lacinia mobilis and substantial setal row, molar absent (except for single seta). Maxillipedal palp of 5 articles, about 3 times as long as endite, the penultimate article proximally broad. Pereopods and antennae ornamented with numerous clubbed setae (plus spines on palms

of subchelate limbs). Uropods overlapping in midline, enclosing pleopods except anteriorly.

Type-species: Chaetilia ovata Dana, 1853 (original designation).

Remarks: Four species of *Chaetilia* are known: *C. ovata* Dana, 1853; *C. paucidens* Menzies, 1962; *C. argentineae* Bastida & Torti, 1970; and *C. tasmanica* sp. nov. The diagnosis accommodates all species as far as they are known. In only the new species described here is a dactyl figured on pereopod 7. The dactyl is minute and obscured by a circle of setae (plate 34b) so could well be missed by earlier authors. Similar minute dactyls have been noted in species of *Microchiridothea* (Moreira, 1973). It seems probable that Menzies (1962) failed to illustrate the suture between articles 2 and 3 of the maxillipedal palp and the limb he called the "third peraeopod" is in fact the fourth. *Chaetilia paucidens* is the only species in which lateral extensions of the head are not visible. This feature does vary with age in *Chiridotea* (Watling and Maurer, 1975) and otherwise the species is consistent with others in the genus.

Chaetilia differs from all other chaetiliid genera in possession of five subchelate or prehensile limbs, the elongate sixth pereopod and very short seventh pereopod. In many respects (head, coxae, pleon, mandible) *Chaetilia* resembles *Macrochiridothea* which differs in having pereopod 1 much more developed than 2 and 3 and pereopods 4-7 ambulatory and similar.

***Chaetilia tasmanica* sp. nov.**

Figures 2-5, Plate 34b, c

Material examined: 7 males, 10.6-12.6 mm; 14 ovigerous females, 15.7-17.6 mm; 9 juveniles, 6.5-15.8 mm; plus numerous unsorted specimens.

Holotype: ovigerous female, 16.8 mm, NMVJ1423 (with 4 slides), Tas., Convict Beach, near Southport (43°27'S., 146°58'E.), intertidal sand beach, A. McGifford, 18 Mar 1981.

Paratypes: Tas., type locality, NMVJ1424 (1 male), NMVJ1425 (7 females), NMVJ1426 (4 males), NMVJ1427 (15 juveniles), NMVJ1428

(140 specimens), TMG2775-2777(12), AMP33877-33879(12).

Other material: Vic., Phillip Is., Woolamai Beach, 21 Dec 1968, NMVJ4113(1).

Description: Body twice as long as greatest width, flattened and without prominent dorsal sculpture. Head with concave frontal margin bearing prominent rostrum; anterior lateral expansion of head acute, setiferous; posterior lateral expansion acute, much smaller. Eye with major dorsal component and minor ventrolateral component directed ventrally through head incision. Pereonites with slight mid-dorsal projections. Coxae 5 and 6 broad plates with bluntly rounded apices, coxa 7 much smaller, not reaching lateral margin. Pleon almost half total body length; pleonite 1 as narrow as pereonite 7, with a mid-ventral semicircular keel bearing about 12 forwardly directed strong setae; epimera of pleonites 2 and 3 faintly convex; pleotelson apically acute and setose.

Antenna 1 reaching posterior margin of pereonite 1; peduncle of stout article 1, more elongate articles 2 and 3; flagellum 0.6 length of last article of peduncle, of 2 articles both with setae and aesthetascs, the first with serrate anterior margin, the second minute. Antenna 2 reaching midway along last article of peduncle of antenna 1; peduncle article 4 the broadest; flagellum of 9 small articles, about as long as last article of peduncle.

Mandible (plate 34c) with toothed calcified incisor; lacinia mobilis asymmetrical, with prominent teeth on left, fine denticles on right; maximum of about 13 setae in setal row; molar absent except for single dorso-anterior long seta near setal row. Maxilla 1 with 11 setae on outer plate, 2 on inner plate. Maxilla 2 notable for a single elongate complex seta on the innermost plate between 3 spines posteriorly and 8 complex setae anteriorly. Maxillipedal endite reaching to distal margin of palp article 2, with stout curved coupling hook and 4 terminal setae; palp articles not lobed medially, the whole elongate-ovate, article 3 the broadest, article 4 the longest, setae only medially; epipod with broad base, subquadrate.

Pereopods 1-3 similar in form, the second slightly larger than either 1 or 3. Articles 4 and 5 each with convex posterior margin bearing



Figure 2. *Chaetilia tasmanica*. Female holotype.

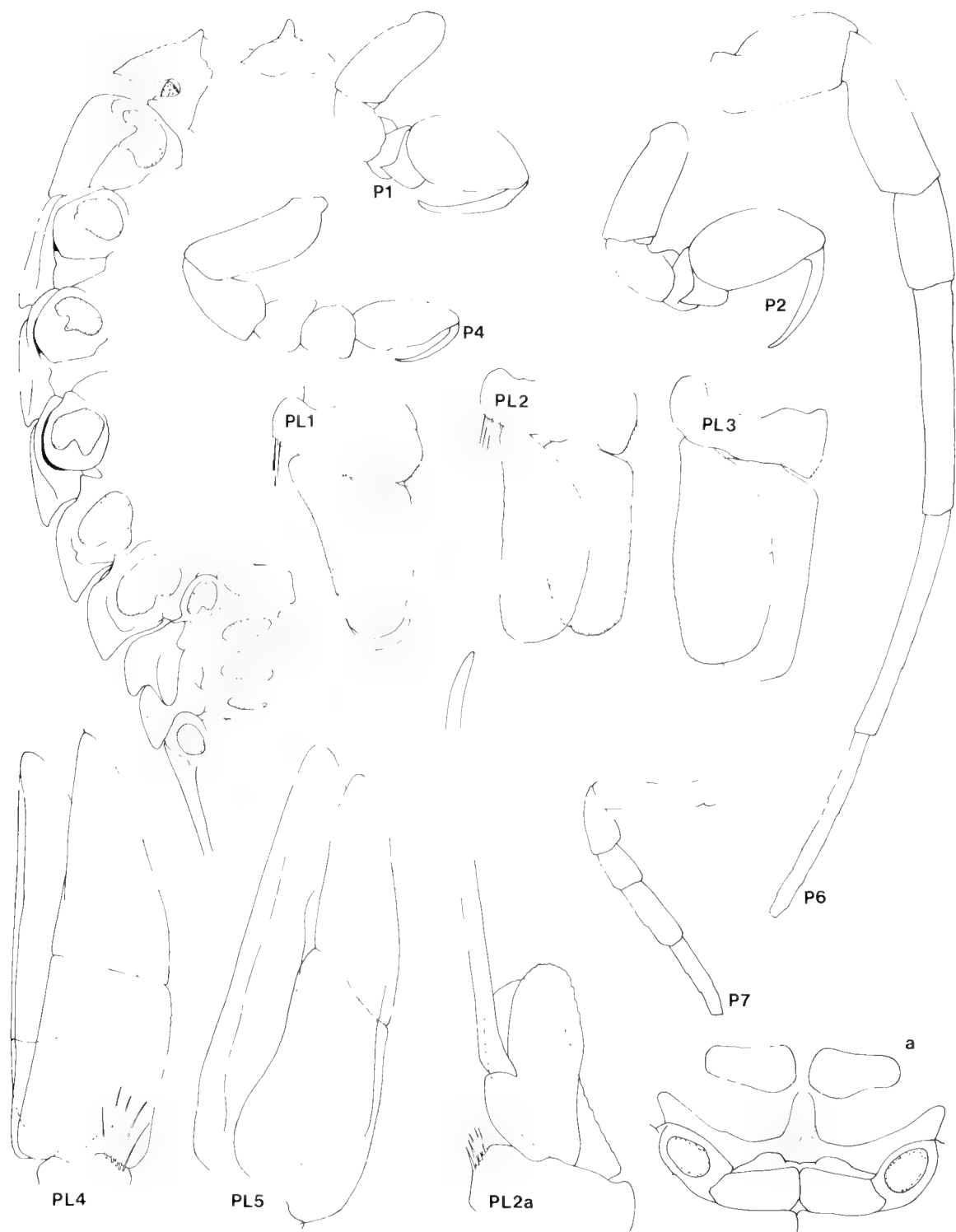


Figure 3. *Chaetilia tasmanica*. Female holotype. a, male, 11.1 mm, NMVJ4124 (Pleopod 2 and sternites of pereonite 7 and pleonite 1). Pereopods to same scale as ventral view and fig. 2.

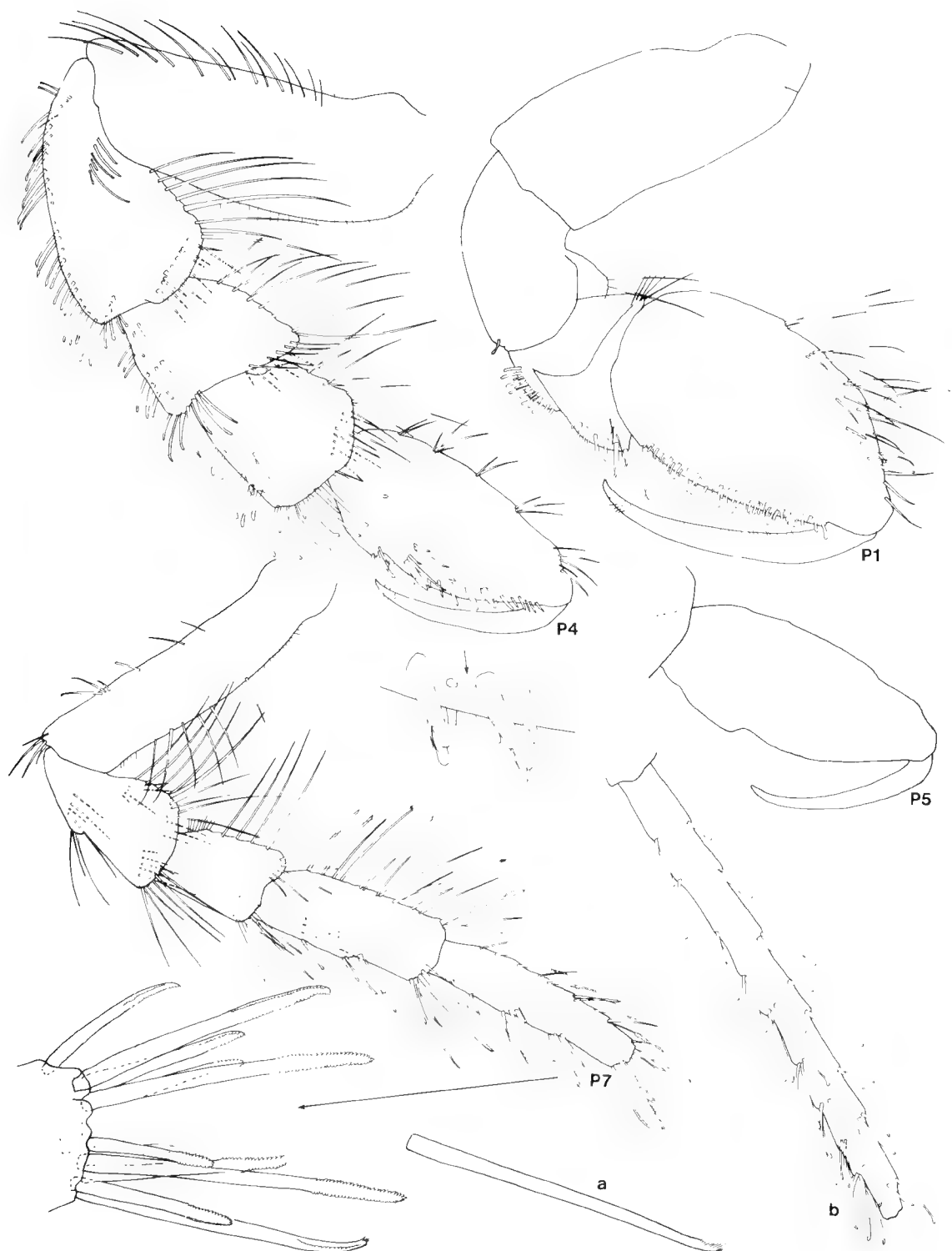


Figure 4. *Chaetilia tasmanica*. Female holotype. a, typical seta from article 4 of pereopod 7. b, dactyl of pereopod 6.

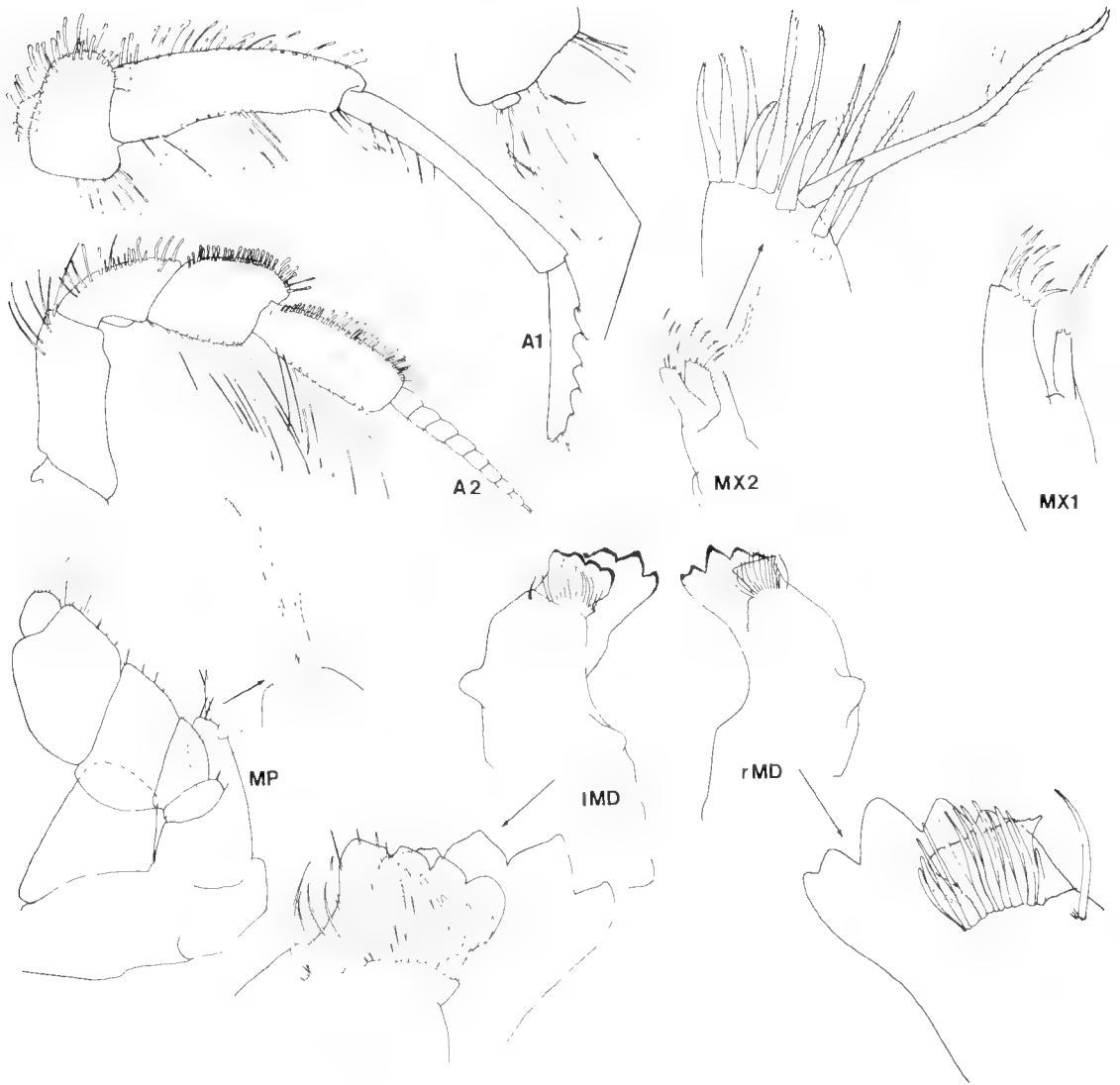


Figure 5. *Chaetilia tasmanica*. Female holotype.

short setae, free distal lobe of article 5 with 2 spines; article 6 ovate, a strong spine at the base of the cutting edge, short setae along it and longer setae on distal half of anterior margin. Pereopods 4 and 5 similar in form, pereopod 5 a little more elongate; article 2-5 with marginal setae plus transverse rows laterally; article 6 with a step proximally and both short setae and spines along both sides of cutting edge; article 7 reaching back only to step in palm. Pereopod 6

as long as total body length, all articles elongate and setiferous. Pereopod 7 about one-third as long as pereopod 6, dactyl minute and bearing terminal seta (plate 34b); articles 2-6 with typical marginal setae but article 6 with additional toothed setae, especially distally (plate 34b).

Pleopods 1-3 with several medial spines on peduncle; rami setiferous. Pleopod 4 larger; exopod of 2 articles, with few short marginal setae, and terminal seta; endopod with partial

suture. Pleopod 5 similar but endopod without suture, exopod without terminal seta.

Uropod not reaching to end of pleotelson; peduncle fitting anteriorly into ventral slot on pleonite 2, outer ramus 0.8 length of inner, both rami ovate, with marginal plumose setae.

Colour in alcohol. Often reddish brown with black spots dorsally and on pereopods 1-6 and uropods.

Male: Differs from juvenile and female only in possession of very short penes and appendix masculina which reaches almost to tip of pleotelson.

Etymology: For the Australian state, Tasmania.

Distribution: Southern, western, eastern coasts of Tasmania, Victoria; sandy beaches.

Remarks: *Chaetilia tasmanica* differs from *C. argentina* in the less elongate antennae and pereopod 6, and from *C. paucidens* in the more pointed pleotelson. In a comprehensive sampling programme for this species McGifford (1981) determined its geographical and ecological distribution. He concluded that the species was confined to semi-exposed beaches all around Tasmania except in the north. Specimens were most abundant at the surface of the sand at mid-low tide levels.

***Stegidotea* gen. nov.**

Diagnosis: Head slightly or moderately laterally expanded, margin not incised. Eyes absent. Pereonites 5-7 only with coxal plates distinct dorsally. Pereonite 7 only slightly narrower than pereonite 6. Pleonite 1 free but not visible laterally; pleonite 2 completely free; pleonites 3 and 4 free laterally only. Pereopods 1-3 prehensile, with cylindrical sixth article cupped proximally by triangular article 5; first larger than others. Pereopods 4-7 ambulatory, pereopod 6 only fractionally the longest. Mandible with toothed incisor, large lacinia mobilis and short setal row; molar prominent, cylindrical, with basal setae. Maxillipedal palp of 5 articles, about 3 times as long as endite, the penultimate article proximally broad. Pereopods and antennae ornamented with few spines (plus numerous minute sigmoid-setae).

Uropods not overlapping, but meeting tightly in midline, enclosing pleopods almost fully.

Type-species: *Stegidotea pinnata* sp. nov.

Etymology: From *stegos* (Greek), a cover, and *Idotea* (type-genus of the family), alluding to the similarity between the type-species and the dinosaur *Stegosaurus*.

Remarks: *Stegidotea* contains two species, both described new here from Bass Strait. In addition to the characters given in the diagnosis several features are shared by the two species. The "stridulatory" ridges across the exopod of pleopod 1 is a character apparently confined to this genus; their function can only be guessed at. The pattern of dorsal sculpture is consistent, only its degree of development differing. The spination of the pereopods and their rectangular-sectioned bases are distinguishing features. The same is true of the uropodal rami, the form of which differs from that in other genera. Another notable minor character is the presence of spines on the fifth article of antenna 2; their form is typical of spines more commonly found on pereopods of other isopods.

Stegidotea most resembles *Glyptonotus* Eight except in having only two (rather than four free pleonites, having toothed (rather than rounded) incisor, and in unequal uropodal rami.

***Stegidotea pinnata* sp. nov.**

Figures 6-9, Plate 34d

Material examined: 3 males, 5.3 mm; 10 juveniles, 4.1-5.3 mm; 5 manca, 2.8-3.8 mm.

Holotype: juvenile, 4.3 mm, NMVJ4144 (with 3 slides), Bass Strait, east of Flinders Is. (39°44.8'S., 148°40.6'E.), fine sand-mud, 124 m, epibenthic sled, 14 Nov 1981 (BSS stn 167).

Paratypes: Bass Strait, type locality, NMVJ4146 (7 specimens); type locality, S-M grab, NMVJ4147(1). Bass Strait, near eastern slope (38°52.6'S., 148°25.2'E.), muddy sand, 140 m, epibenthic sled, 15 Nov 1981 (BSS stn 170), NMVJ4145 (1 male), NMVJ4148(6).

Other material: Bass Strait, off Cape Otway (39°05'S., 143°09'E.), 47 m, pipe dredge, 8 Oct 1980 (BSS stn 58), NMVJ8563(1). Bass Strait, western slope near King Island (40°06'S., 143°18'E.), 139 m, S-M grab, NMVJ8564(1).



Figure 6. *Stegidotea pinnata*. Juvenile holotype. (Ventral view shown with right antennae, mouthparts, pereopods, pleopods and uropod removed). a, locking catch at anteroventral margins of uropod pair.

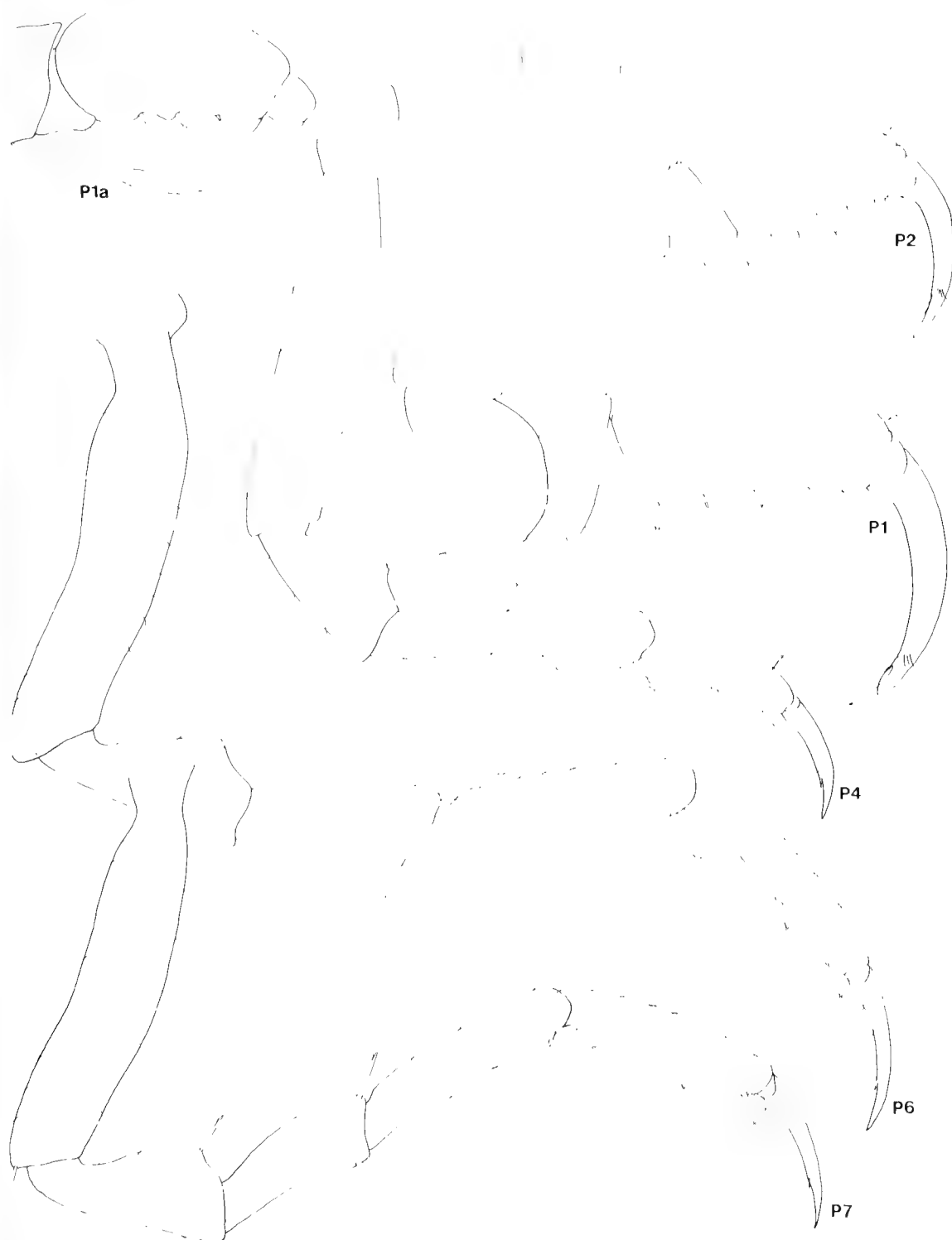


Figure 7. *Stegidotea pinnata*. Juvenile holotype. a, male paratype, 5.3 mm, NMVJ4145 (pericopod 1).

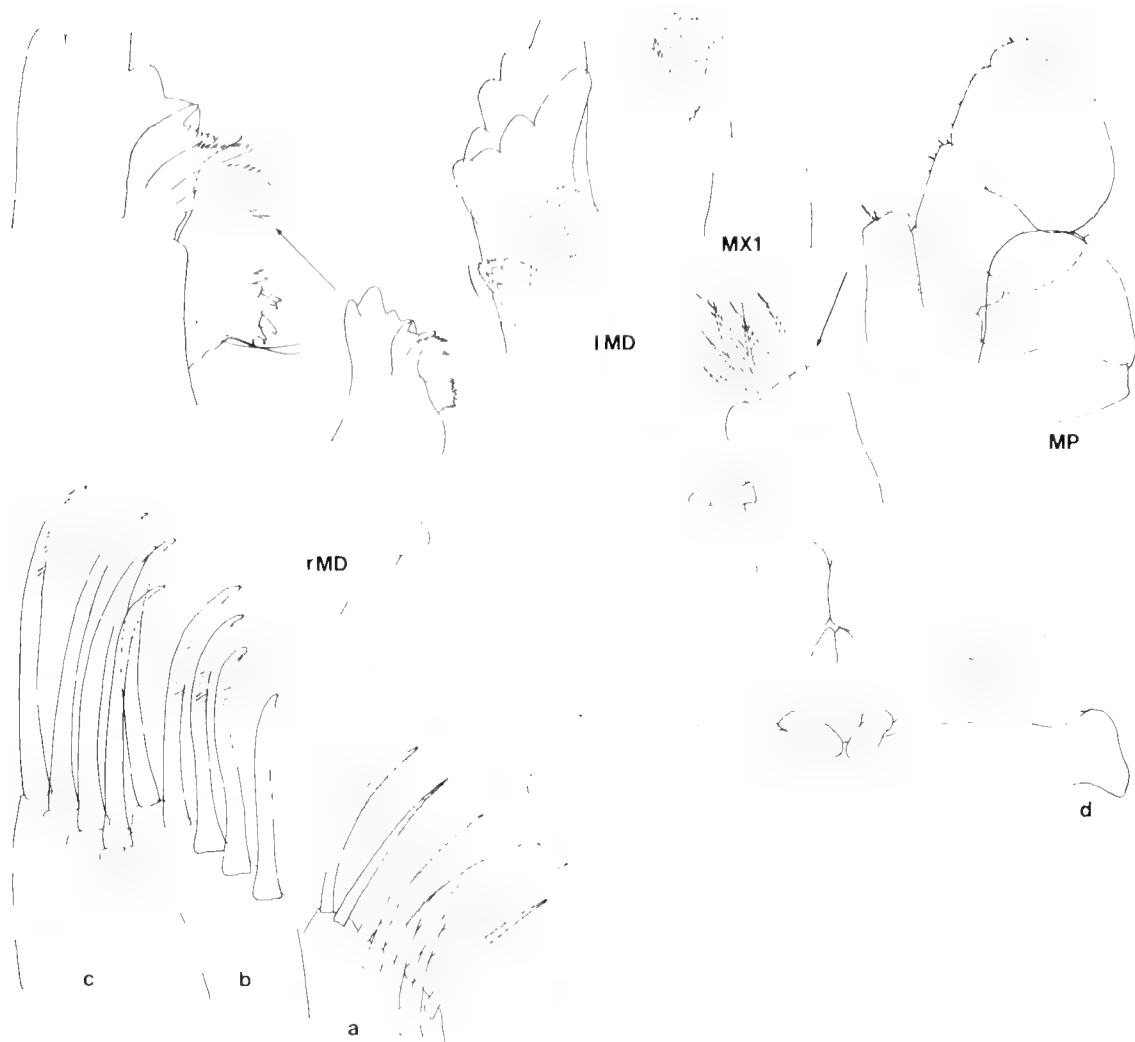


Figure 8. *Stegidotea pinnata*. Juvenile holotype. a, b, c, inner, middle and outer rami of maxilla 1. d, male paratype, 5.3 mm, NMVJ4145 (sternites of pereonite 7 and pleonite 1 with penes).

Tas., east of Maria Island ($42^{\circ}37'S$, $148^{\circ}20'E$), 102 m, epibenthic sled, 9 Oct 1984 (BSS stn 221), NMVJ10924(3).

WA, North-west shelf, $20^{\circ}20.8'S$, $115^{\circ}58.9'E$, 42 m, epibenthic sled, 9 June 1983, NMVJ7765(1), J7766(1).

Description: Female. Body 1.8 times as long as greatest width, dorsoventrally quite convex; pleonal cavity enclosed by uropods dominates the posterior half in lateral view. Integument without any fine surface sculpture dorsally but

uropods have reticulate patterning. Head with concave frontal margin with small ventral rostrum; lateral expansion of head triangular; an oblique curved lateral ridge connects with frontal margin; top of head faintly rugose. Pereonites 1-7 with prominent mid-dorsal backwardly-curved carinae; smaller lateral carinae on pereonites 1-6. Coxae 5-7 rectangular plates with more or less square apices, coxa 7 shorter than others. Pleon about 0.45 total body length, with 2 mid-dorsal long carinae posterior to complete sutures; pleonite

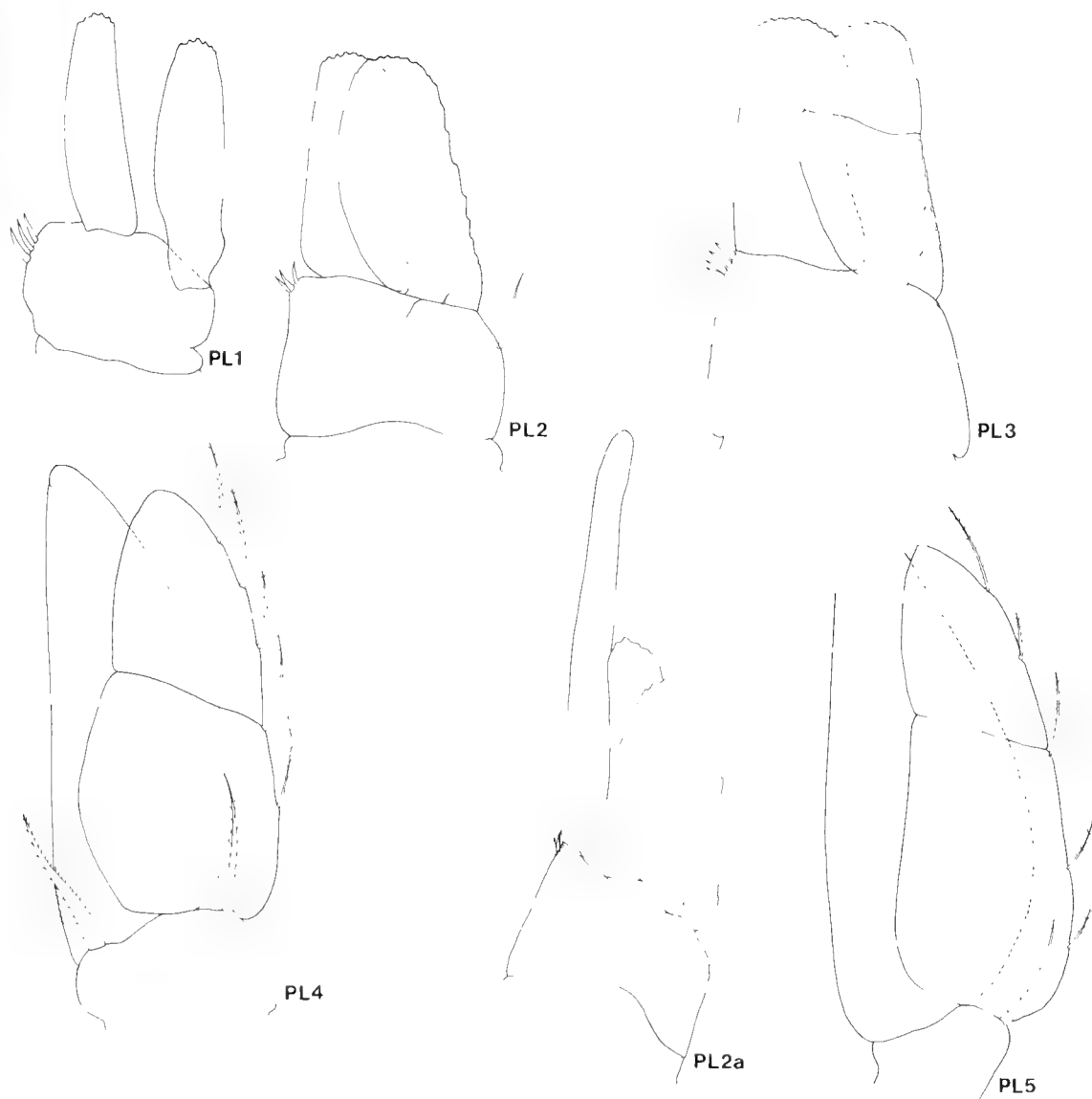


Figure 9. *Stegidotea pinnata*. Juvenile holotype. a, male paratype, 5.3 mm, NMVJ4145 (pleopod 2). Pleopods 1-3 shown without setae.

1 narrow, unarmed, free; pleonal epimera 2-4 diverging markedly such that base of pleotelson is noticeably narrower than pleonite 4; pleotelson apically rounded.

Antenna 1 reaching as far as side of head, to end of antenna 2 peduncle; peduncle article 3 the longest, with only minute setae; flagellum half length of last article of peduncle, of 2 articles, the second narrow and minute, both with

terminal aesthetascs and setae. Antenna 2 reaching just beyond lateral margin of head; peduncle article 5 longer than 3 and 4, with 2 short ventral spines near anterior margin; flagellum as long as last article of peduncle, first article elongate-ovate, flattened, second and third much shorter.

Mandible with toothed incisor; lacinia mobilis asymmetrical, left as large as the incisor

and with prominent broad teeth, right much smaller and with rows of fine teeth and denticles (plate 34d); 3 complex spines in spine row; molar a cylindrical process on anterior margin, surrounded by fine spines, bearing 1 or 2 long basal setae proximally. Maxilla 1 with 11 setae on outer plate, 2 on inner plate. Maxilla 2 inner ramus bearing 6 apical setae and 3 shorter setae. Maxillipedal endite reaching just beyond distal margin of palp article 2, with straight coupling hook and 6 apical setae plus 1 subapical seta; palp ovate, articles 3 lobed medially, articles 3 and 4 the broadest; setae only medially; epipod semi-elliptical.

Pereopods 1-3 similar in form, first the longest, second only slightly larger than the third. Pereopod 1 article 5 with single posterior spine, article 6 cylindrical, palm straight, with 2 spines. Pereopods 2 and 3 with 1 spine anteriorly on article 3, 2 posterior spines on article 5 and 3 on article 6. Pereopods 4-7 similar, ambulatory, the sixth the longest (little more than half total body length); articles 4-6 each armed posteriorly with 1-3 spines, article 3 with spine on an anterior lobe, article 4 with 1 or 2 spines on disto-anterior margin.

Pleopod 1 with 3 medial spines on peduncle, rami narrow and not overlapping, endopod with 5 terminal long plumose setae; exopod with 5 terminal setae and 30 transverse closely spaced "stridulatory" ridges on posterior surface. Pleopod 2 with overlapping rami 1.5 times as long as peduncle, endopod setose terminally, exopod marginally setose except along proximal part of medial margin. Pleopod 3 peduncle longer than on pleopod 2, setal distribution similar, exopod with 2 articles. Pleopods 4 and 5 similar, peduncle with plumose setae; endopod without setae; exopod with 2 articles and 5 setae laterally.

Uropod peduncles locked by small catch anteriorly to form pleonal cavity (see figure), each with single terminal medial seta; inner ramus narrow, reaching 0.8 length of outer ramus, with 5 very short setae on oblique distal margin.

Colour in alcohol. White or dull brown.

Male: No gross morphological differences from juvenile except that palm of pereopod 1 has

small projections at the base of each spine. Penes are paired and well-spaced. Appendix masculina almost twice as long as pleopod 2 endopod and almost as broad.

Etymology: From *pinn*a (Latin), a fin, so named because of the species' dorsal ornamentation.

Distribution: Bass Strait and east coast of Tasmania, muddy sand, 47-140 m, and North-west shelf.

Remarks: *Stegidotea pinnata* is immediately distinguished from its cogenor in Bass Strait by the prominent dorsal ornamentation and the diverging pleonal epimera. The species has a more restricted geographical distribution in Bass Strait than *S. scabra* and occurs on more muddy sediments at greater depths.

The occurrence of a temperate Australian isopod in tropical benthos is not anticipated. Current research on other families has not found a similar distributional record.

Stegidotea scabra sp. nov.

Figures 10-12, Plate 34e, f

Material examined: 2 males, 5.6 mm; 1 ovigerous female, 5.2 mm; 8 juveniles, 3.0-5.3 mm.

Holotype: ovigerous female, 5.2 mm, NMVJ4152 (with 3 slides), Vic., north-eastern Bass Strait (38°54.3'S., 147°13.4'E.), coarse shell, 58 m, S-M grab (BSS stn 176).

Paratypes: Vic., off Warrnambool (38°49.5'S., 142°35.4'E.) sand and coarse shell, 89 m, rock dredge (BSS stn 190), NMVJ4153 (2 males). SE. of Cape Otway (39°16.7'S., 143°06.7'E.), sandy shell, 95 m, rock dredge (BSS stn 193), NMVJ4154(3). North-eastern Bass Strait (39°16.8'S., 147°33.2'E.) muddy shell, 57 m, epibenthic sled (BSS stn 174) NMVJ4157(2); (39°05.8'S., 147°26.2'E.), coarse shell, 59 m, epibenthic sled (BSS stn 175), NMVJ4156(1). Off north-eastern Tasmania (40°40.7'S., 148°36.9'E.), muddy sediment, 67 m, epibenthic sled (BSS stn 164), NMVJ4155(2).

Description: Female. Body 2.0 times as long as greatest width, dorsoventrally convex; pleonal cavity enclosed by uropods dominates posterior half in lateral view. Integument with reticulate raised pattern confined on pereonites to

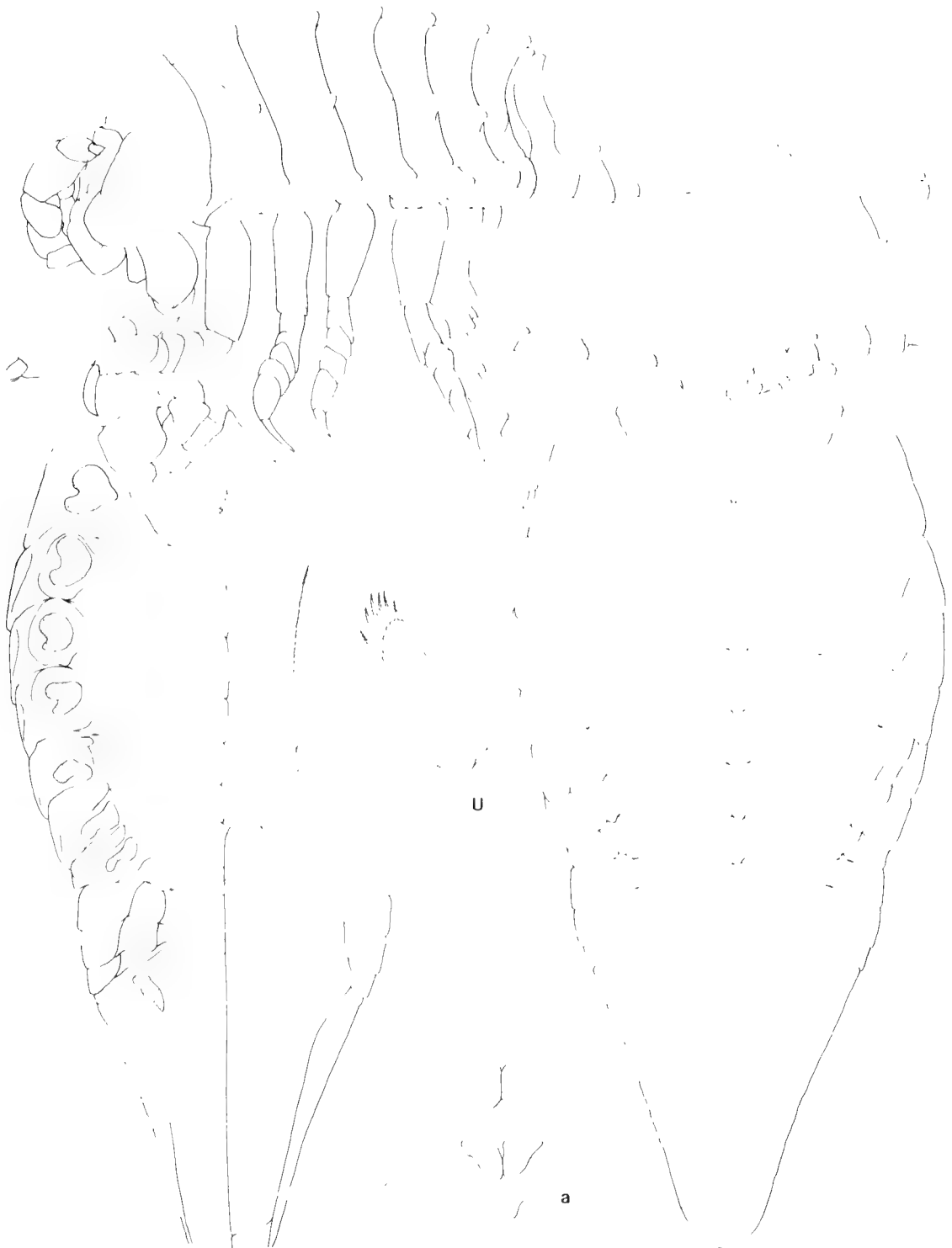


Figure 10. *Stegidotea scabra*. Juvenile holotype. a, male paratype, 4.1 mm NMVJ4153 (sternites of pereonite 7 and pleonite 1 with penes).

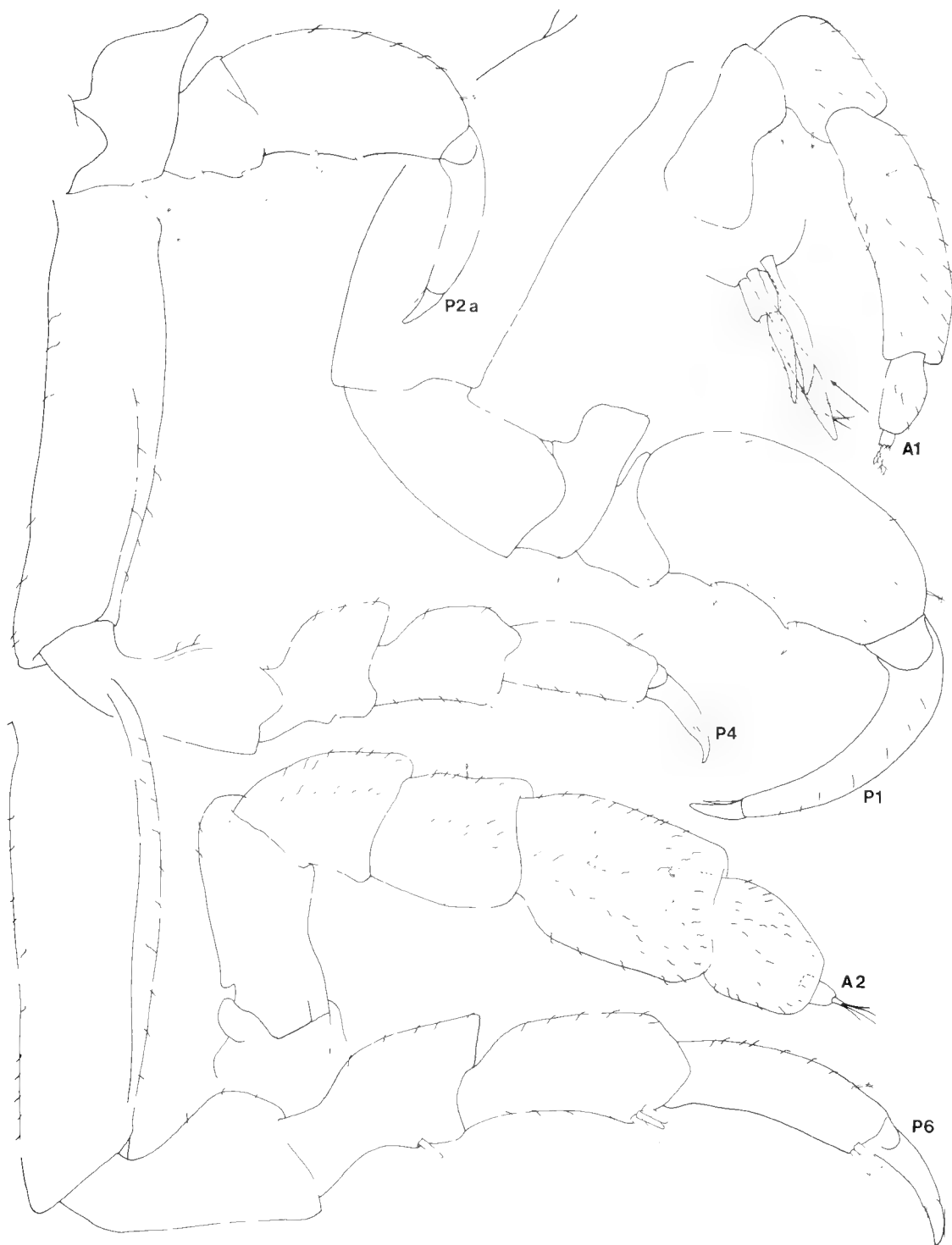


Figure 11. *Stegidotea scabra*. Juvenile holotype. a, male paratype, 4.1 mm NMVJ4153 (pereopod 2).



Figure 12. *Stegidotea scabra*. Juvenile holotype. a, male paratype, 4.1 mm NMVJ4153 (pleopod 2 endopod).

transverse ridges; the inter-ridge spaces extremely finely and regularly denticulate. Head with concave frontal margin with very small ventral rostrum; lateral expansion of head triangular but obscured from dorsal view by anterior part of pereonite 1; top of head rugose and irregularly ridged. Pereonites 1-7 with low mid-dorsal broadly-based carinae; smaller lateral carinae on pereonites 2-6; pereonite 1 dorsally rugose, especially laterally, others with small tubercles on transverse ridges between carinae. Coxae 5-7 rectangular plates with more or less square apices, lateral convex margins aligned. Pleon about 0.45 total body length, mid-dorsally domed on anterior two-thirds, with a slight step posterior to free pleonites, otherwise irregularly sculptured; pleonite 1 short, narrow, free; pleonite 2 free; pleonal epimera 2-4 converging slightly such that margin of whole pleotelson is a continuous curve; pleotelson apically rounded.

Antenna 1 reaching near to lateral margin of head, not to end of peduncle of antenna 2; peduncle article 3 narrow, about as long as first 2 together; flagellum one-third length of last article of peduncle, of 2 articles, the second minute, both bearing terminal aesthetascs. Antenna 2 reaching to lateral margin of pereonite 1; peduncle article 5 the longest, with 2 ventral spines; flagellum almost as long as peduncle article 5, partly embedded in it, first article broadly ovate, second and third much shorter.

Mandible with toothed incisor; lacinia mobilis asymmetrical, left as wide as incisor and with 3 broad teeth (pl. 34f, g), right less than half width of incisor and with rows of denticles and fine teeth (pl. 34e); 2-3 complex spines in spine row; molar a cylindrical toothed process bearing numerous sharp teeth and 2 basal setae. Maxillae typical. Maxillipedal endite reaching midpoint of third palp article, with 1 coupling hook and 8 apical setae; palp ovate, article 3 lobed medially and enclosing article 4 laterally, articles 3 and 4 the broadest; setae only medially; epipod semi-elliptical.

Pereopods 1-3 similar in form, first the largest, second only slightly longer than third. Pereopod 1 article 5 with single posterior spine; article 6 cylindrical, palm with 2 spines on small

projections. Pereopods 2 and 3 with 1 spine on article 4, 2 each on articles 5 and 6. Pereopods 4-7 similar, ambulatory, sixth the largest; article 4 with 1 spine near midpoint of posterior margin; articles 5 and 6 with 1-3 spines at distoposterior angle.

Pleopod 1 with 2 medial spines on peduncle, rami narrow and not overlapping; endopod with 6 terminal long plumose setae; exopod with 5 terminal setae and about 30 transverse closely spaced "stridulatory" ridges on the posterior surface. Pleopod 2 with overlapping rami, 1.5 times as long as peduncle; endopod setose terminally; exopod setose except along proximal part of medial margin. Pleopod 3 setal distribution similar to that of pleopod 2. Pleopods 4 and 5 similar, peduncle with terminal plumose seta; endopod without setae; exopod of 2 articles, with 4-5 setae laterally.

Uropod peduncle locked by small catch anteriorly to form pleonal cavity, sculptured with reticulate pattern and denticles similar to that occurring dorsally; peduncle with a terminal plumose seta; inner ramus subtriangular, non-setose (except for 2 brush-setae externally); outer ramus narrow; parallel-sided, 0.8 length of outer ramus, with 6 plumose setae on the oblique convex terminal margin.

Colour in alcohol. White.

Male: No marked morphological differences from the female and juvenile. Penes are paired and well spaced. Appendix masculina a little more than twice as long as pleopod 2 endopod and almost as broad.

Colour in alcohol. White.

Etymology: From *scabrus* (Latin) rough, referring to the species' sculpture.

Distribution: Bass Strait, sandy sediment, 58-95 m.

Remarks: *Stegidotea scabra* is distinguished from *S. pinnata* by the less pronounced dorsal crests, its surface sculpture and slight lateral development of the pleonites. The species is widespread in Bass Strait at intermediate depths.

Acknowledgements

This contribution is based largely on collections made possible through funding by an

Australian Department of Sciences Marine Science and Technologies grant to the Museum of Victoria. I am especially indebted to Andy McGifford who drew my attention to the presence of *Chaetilia tasmanica* in Tasmania and provided material for study. Thanks to Richard Brusca for comments on the manuscript. The Victorian Ethnic Affairs Commission kindly arranged for a translation from Russian of sections of Kussakin's paper. I am also grateful to Linda Crosby, Department of Zoology, University of Melbourne, who prepared the electron micrographs.

References

- BOWMAN, T. E. & ABLE, L. G., 1982. Classification of the Recent Crustacea. Pp. 1-27 in *The Biology of Crustacea* (Editor-in-chief, Bliss, D. E.) Vol. 1, *Systematics, the fossil record, and biogeography* (Ed., Able, L. G.). Academic Press: New York.
- BRUSCA, R. C., 1984. Phylogeny, evolution and biogeography of the marine isopod subfamily Idoteinae (Crustacea: Isopoda: Idoteidae). *Trans. San Diego nat. Hist. Soc.* 20: 99-134.
- BRUSCA, R. C. & WALLERSTEIN, B. R., 1979. The marine isopod Crustacea of the Gulf of California. II. Idoteidae: New genus and species, range extensions, and comments on evolution and taxonomy within the family. *Proc. biol. Soc. Wash.* 92: 253-71.
- DANA, J. D., 1853. Crustacea. Part II. *U.S. explor. Exped.* 13: 691-1618.
- ELKAIM, B. & DAGUERRE DE HUREAUX, N., 1976. Contribution à l'étude des isopodes marins: le genre *Parachiridotea* et la sous-famille nouvelle de Parachiridoteinae (Valvifère, Idoteidae). *Archs. Zool. exp. gen.* 117: 275-93.
- HURLEY, D. E. & MURRAY, R. H., 1968. A new species of *Macrochiridothea* from New Zealand, with notes on the idotheid subfamily Chaetiliinae (Crustacea: Isopoda: Valvifera). *Trans. R. Soc. N.Z. (Zool.)* 10: 241-9.
- JONES, M. B. & FENWICK, G. D., 1978. *Maoridotea naylori*, a new genus and species of isopod (Valvifera, Idoteidae, Chaetiliinae) from the Kaikoura Peninsula, New Zealand. *J. nat. Hist.* 12: 617-25.
- KUSSAKIN, O. G., 1979. Marine and brackish-water Isopoda of cold and temperate waters of the Northern Hemisphere. Elabellifera. *Opred. Faune SSSR* 122: 1-472. In Russian.
- MCGIFFORD, A. J., 1981. The taxonomy and ecology of a new species of *Chaetilia* (Isopoda, Idotheidae) from Tasmanian sandy beaches. B.Sc. (Hons) thesis, University of Tasmania, Hobart. 112 pp.
- MENZIES, R. J., 1962. The zoogeography, ecology and systematics of the Chilean marine isopods. *Acta. Univ. Lund.* (2) 57: 1-162.
- MILNE, E. J., 1881. Revision of the Idoteidae, a family of sessile-eyed Crustacea. *J. Linn. Soc.* 16: 1-88.
- MOREIRA, P. S., 1973. Species of *Macrochiridothea* Ohlin, 1901 (Isopoda, Valvifera) from southern Brazil, with notes on remaining species of the genus. *Bolm Inst. oceanogr., S. Paulo* 22: 11-47.
- POORI, G. C. B., 1978. *Austrochaetilia capeli*, a new genus and species of chaetiline idoteid (Isopoda) from Port Phillip Bay, Australia. *Crustaceana* 33: 113-18 (volume for 1977).
- POORI, G. C. B., 1984. Clarification of the monotypic genera *Chiriscus* and *Symmus* (Crustacea: Isopoda: Idoteidae). *Proc. biol. Soc. Wash.* 97: 71-7.
- RACOVITZA, E. F. & SEVASTOS, R., 1910. *Proidotea haugii* n.g. n. sp. Isopode Oligocene de Roumanie et les Mesidoteini nouvelle sousfamille des Idoteidae. *Archs. Zool. exp. gen.* 46: 175-200.
- SHEPPARD, E. M., 1957. Isopod Crustacea. Part II. 'Discovery' Rep. 29: 141-98.
- WAITING, I. AND MAURER, D., 1975. *Chiridotea stenops* Menzies and Frankenberg, a juvenile of *C. arenicola* Wigley (Crustacea: Isopoda). *Proc. biol. Soc. Wash.* 88: 121-6.

Explanation of Plate

PLATE 34. Scanning electron micrographs of mandibles and pereopod of species of Chaetiliidae (Isopoda). *Austrochaetilia capeli*: a, left mandible; *Chaetilia tasmanica*: b, tip of pereopod 7; c, left mandible; *Stegidotea pinnata*: d, right mandible; *Stegidotea scabra*: e, right mandible; f, g, left mandible.

